



OPERATOR'S MANUAL

BALDWIN-LIMA-HAMILTON CORP.

EDDYSTONE DIVISION

PHILADELPHIA 42, PA.



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NO. DF-108

THE RF-16 DIESEL ELECTRIC
FREIGHT LOCOMOTIVE
WITH
DYNAMIC BRAKING

* * * *

BALDWIN-LIMA-HAMILTON CORPORATION
PHILADELPHIA, PENNA., U.S.A.

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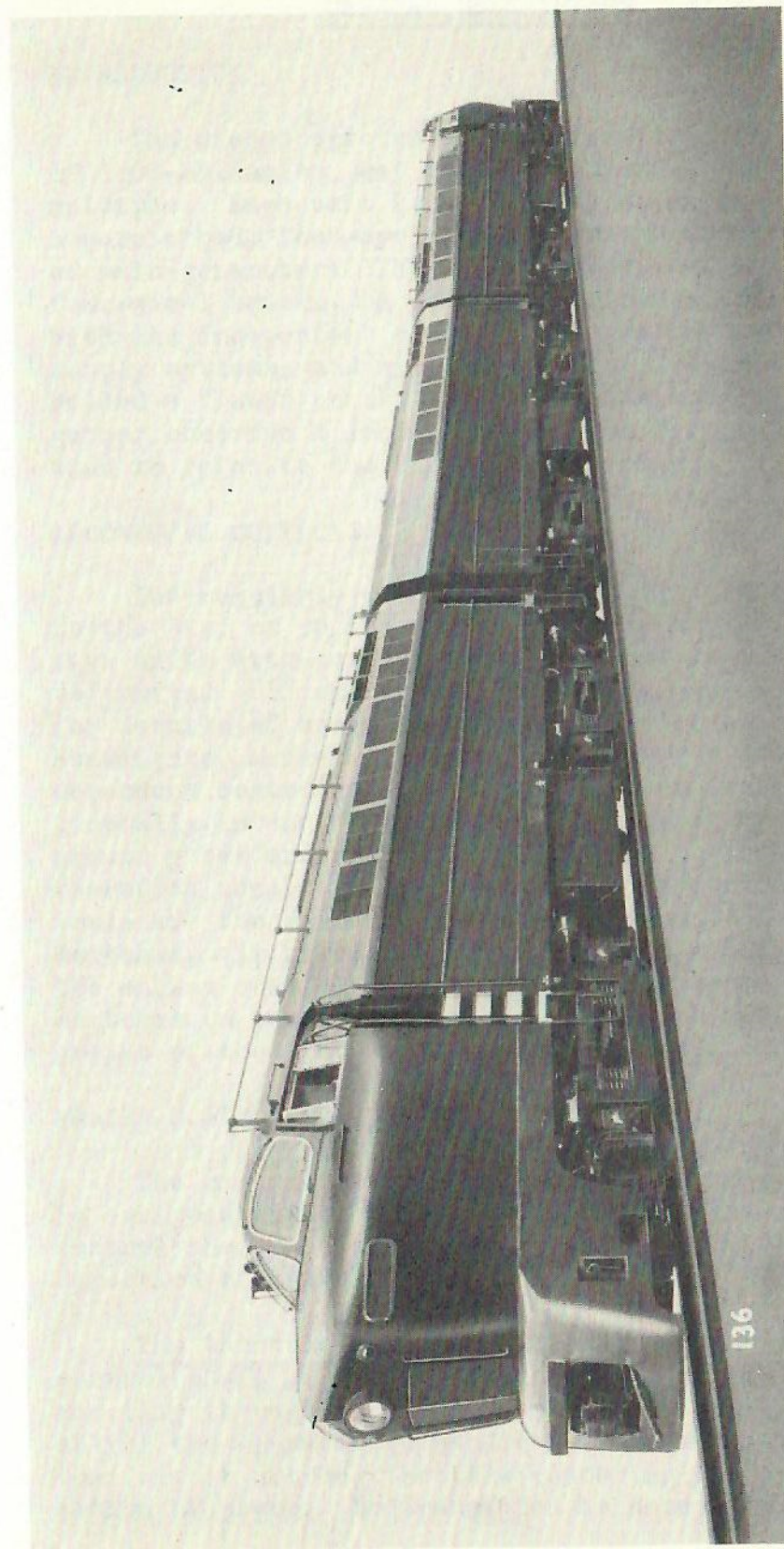
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VIEW OF LOCOMOTIVE
Figure 1

GENERAL DESCRIPTION

INTRODUCTION

The diesel electric road locomotive, consisting of 1600-hp. units, may be used either singly or in multiple. Each unit is powered by an eight-cylinder, supercharged, four-cycle engine, with direct connected main generator. The running gear consists of two four-wheel trucks. A complete engine-generator set with its independent cooling, lubricating and fuel supply systems, and similar auxiliary equipment is called a "power unit". Several units coupled together comprise a locomotive and the term "engine" is used to refer to the diesel engine only.

LOCOMOTIVE CONTROLS

The regularly used manual controls are located in the cab, or on the engine control panel. Locomotive units with complete sets of controls are called "A" units. "B" units are like the "A" units except for details of controls, and accessories such as headlights, marker lights and signaling systems. Independent control of the "B" unit (when installed) is generally intended for necessary handling by a hostler around yards and roundhouses, and the controls are therefore considerably simplified. The principal controls are the master controller, the control stand switches, air brakes and miscellaneous cab equipment, the engine control panel in the engine room, and switches in the electrical equipment cabinet. Photographs of these controls appear on subsequent pages.

MASTER CONTROLLER

The master controller at the engineer's position is equipped with a throttle and reverse lever which control the speed and power of the locomotive and its direction of travel.

The throttle acts pneumatically on the speed control shaft of the engine governor. It is advanced smoothly through an infinite number of positions, enabling the operator to handle a train more smoothly than with a notched throttle rendering stepped application of power. No transition is necessary.

The reverse lever usually has three positions, Forward, Reverse and Off, which are clearly marked.

If the locomotive is equipped for dynamic braking, additional positions are provided on "A" units. ("B" units will brake dynamically only when controlled from an "A" unit). The reverse lever is interlocked with the throttle so that it cannot be moved except when the throttle is off.

BRAKES

Air Pressure Gauges for (a) the Brake Pipe and Cylinder and (b) the Main and Equalizing Reservoir are located on the instrument panel in front of the engineer.

The automatic brake valve is located near the top of the brake pedestal in front of the engineer's position, with the lever at the engineer's right hand. No automatic brake valve is provided on "B" units.

The independent brake valve is mounted between the automatic brake valve and the master controller. It controls the locomotive brakes only.

A Rotair Valve is mounted on the bulkhead of "A" units. This valve is manually operated to adjust braking power to the particular requirements of the service in which the locomotive is being operated.

A hand brake is situated on the side wall of the radiator compartment of each "A" and "B" unit.

MISCELLANEOUS CAB CONTROLS

The horn, bellringer, window wipers, defrosters, cab heaters, headlight and sanders are standard miscellaneous items of equipment controlled from the cab of "A" units. Hot water cab heaters are equipped with electric fans whose speed can be controlled by rheostats in the cab. A breaker type switch (usually in the cabinet) feeds both heater circuits. Slight changes may be required from standard cab layout if there are many controls for extra equipment, such as window washers, train control, train communication, cab signals, etc.

A speed indicator is mounted in the cab to show locomotive speed. Extra equipment which may be installed in conjunction with the indicator are a tape recording device, and an automatic brake application feature.

Overspeed control, when incorporated in the recorder, is actuated by a micro-switch in the recorder which opens when train speed becomes excessive. This de-energizes an overspeed magnet valve which sounds an overspeed whistle in the cab and changes the pressure in the overspeed air reservoir. When this device is equipped with a recapture feature, the engineer must apply the brakes promptly (30 lb. reduction) in order to avoid a penalty application. If the engineer does not reduce the speed within a short time delay interval, the brakes are automatically applied. When an automatic application occurs, the automatic brake must be placed in Lap until recovery of the brake system, and the throttle must be returned to the off position before normal operation can be resumed.

ENGINE CONTROL PANEL

The control panel on the engine side of the electrical equipment cabinet along the left aisle of each "A" and "B" unit contains switches for starting, stopping, and idling the engine, connecting the fuel pump motor to its power supply, and manually controlling the fans. Gauges, indicating lights and switches for other miscellaneous purposes, as designated by their nameplates, are on the panel or the adjacent wall.

ELECTRICAL EQUIPMENT CABINET

An equipment cabinet, located behind the cab in "A" units, contains most of the electrical equipment on the locomotive. A photograph in the Electrical Section shows the arrangement of the equipment in the cabinet. Cabinets on "B" units are in the same relative position behind the hostler's controls, and are almost identical with "A" units in arrangement.

The manually controlled switches inside the standard equipment cabinet are the battery switch, power cutout switch, traction motor cutout switch, and breakers in the auxiliary generator, fan and lighting control circuits.

SAFETY NOTICE

High voltages are used on much of the equipment in the cabinets. Cabinet doors should be kept closed as much as possible. No attempt should be made by unqualified personnel to open the doors or make adjustments to equipment.

TRACTION MOTOR BLOWERS

The motors are cooled by blowers which are belt-driven by the diesel engine. Ducts lead from the blowers to the motors through the locomotive under-frame. The heavy currents generate heat which will damage the motors if they are not adequately cooled. A unit should be isolated or shut down if its blowers are not functioning properly.

ENGINE COOLING

Electrically driven fans draw air through the engine radiators located in the sides of the radiator compartment in the end of each unit. An engine driven pump forces the cooling water through the radiators. This water also cools the lubricating oil through the medium of a heat exchanger in each radiator compartment. See Section 3.

TURBOCHARGER

Each engine is supercharged by a turbocharger, a self-contained unit consisting of a gas turbine and centrifugal blower rotating on a common shaft. The unit is located at the end of the engine over the main generator. The turbine uses the energy in the exhaust gases to drive the blower, which supplies air to the engine cylinders at a pressure above atmospheric pressure. It is lubricated by the engine lubricating system and cooled by the engine cooling system. There are two water drain cocks, one in the cooling system and one for condensation.

D I E S E L E L E C T R I C L O C O M O T I V E

STANDARD "A" AND "B" UNITS

G E N E R A L D A T A

B.L.W. LOCOMOTIVE CLASSIFICATION ... RF-16

GAUGE 4' - 8 1/2"

WHEEL ARRANGEMENT (Each Unit) 0-4-4-0
Two Four-Wheel Swivel Trucks

DIESEL ENGINES 1600 HP
One Model 608 A 8-Cylinder In-Line
Supercharged Engine per Unit

MAIN GENERATORS Westinghouse
One per Unit 471-A

TRACTION MOTORS Westinghouse
Four per Unit 370-G

GEAR RATIO AND MAXIMUM SPEED 15:68 65 MPH
15:63 70 MPH
17:62 80 MPH

STARTING TRACTIVE EFFORT
"A" Unit, 25% Adhesion* 62,000 Lbs.
"B" Unit, 25% Adhesion* 61,000 Lbs.
* Without Dynamic Braking Equipment

CURVES, MINIMUM RADIUS
Locomotive with Train 273' (21°)

WHEELS (per Unit)
Driving 4 Pairs
Diameter 42"

WHEEL BASE

Trucks (Each) 9' - 10"

LOCOMOTIVE DIMENSIONS

Length "A" Units (Each) 54' - 8"
Length "B" Units (Each) 53' - 2"
Height, Overall 15' - 0"
Width, Overall 10' - 6"

WEIGHT

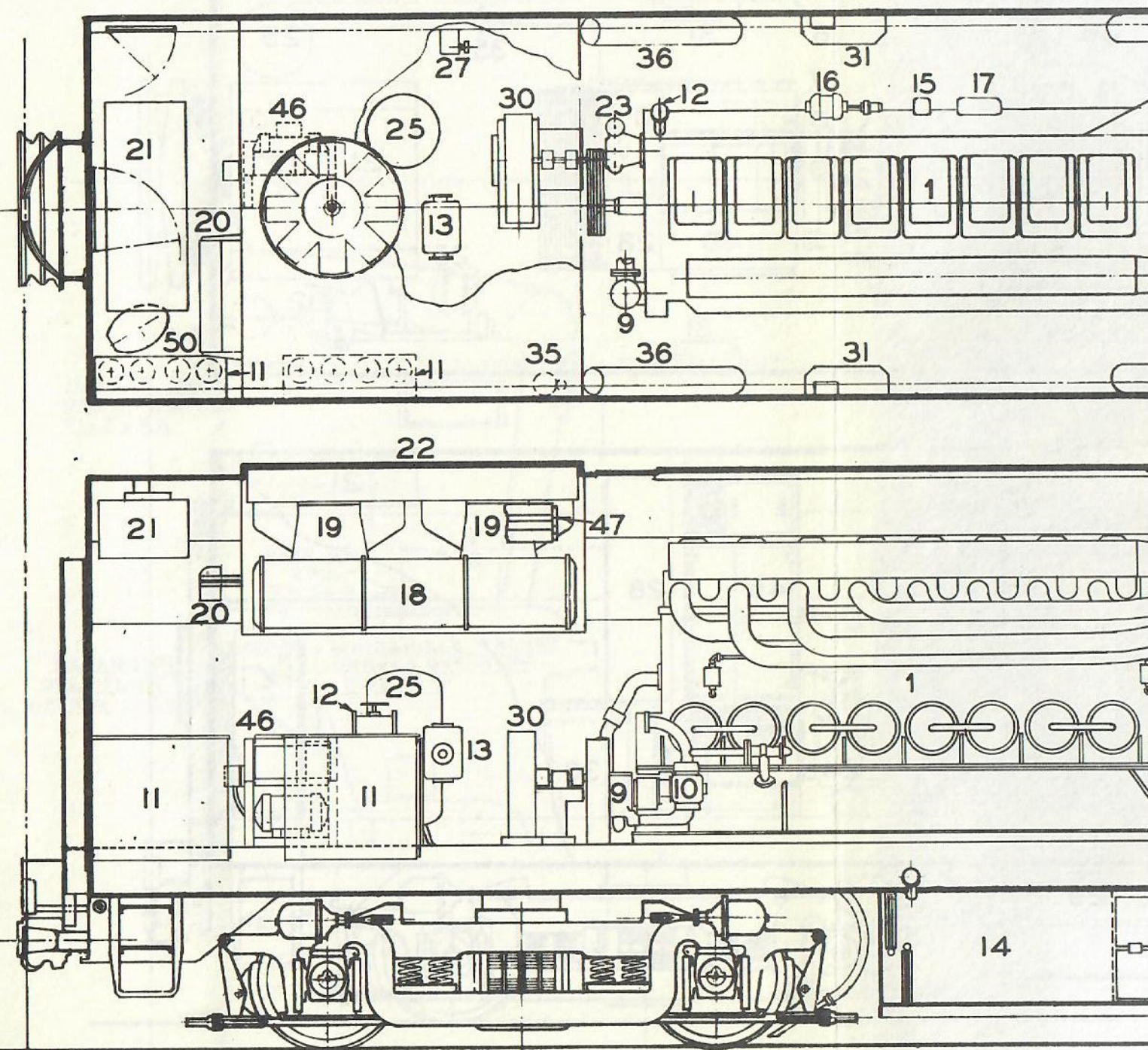
"A" Units (Each - Approx.) 248,000 Lbs.
"B" Units (Each - Approx.) 214,000 Lbs.

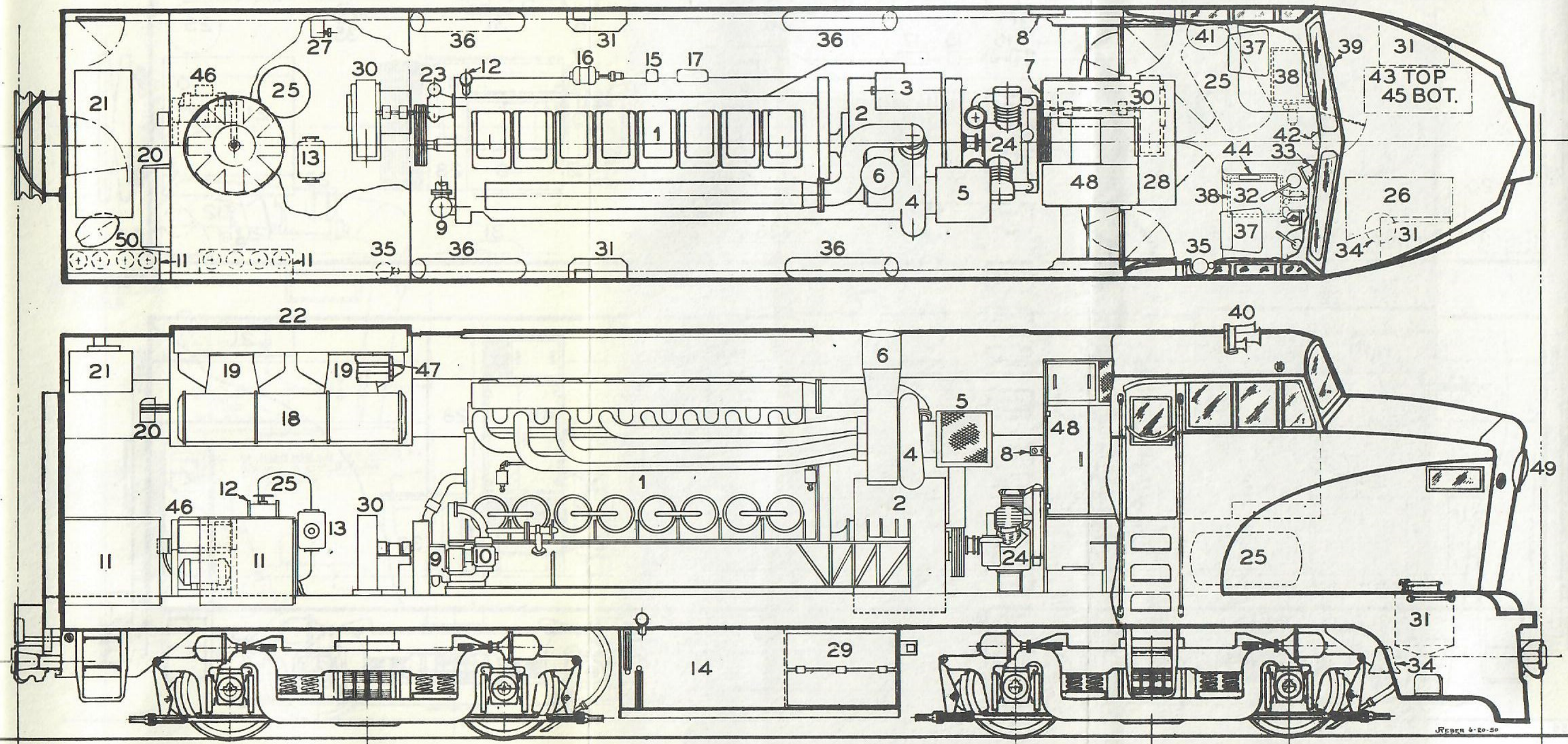
Traction Motor, Gear and Axle

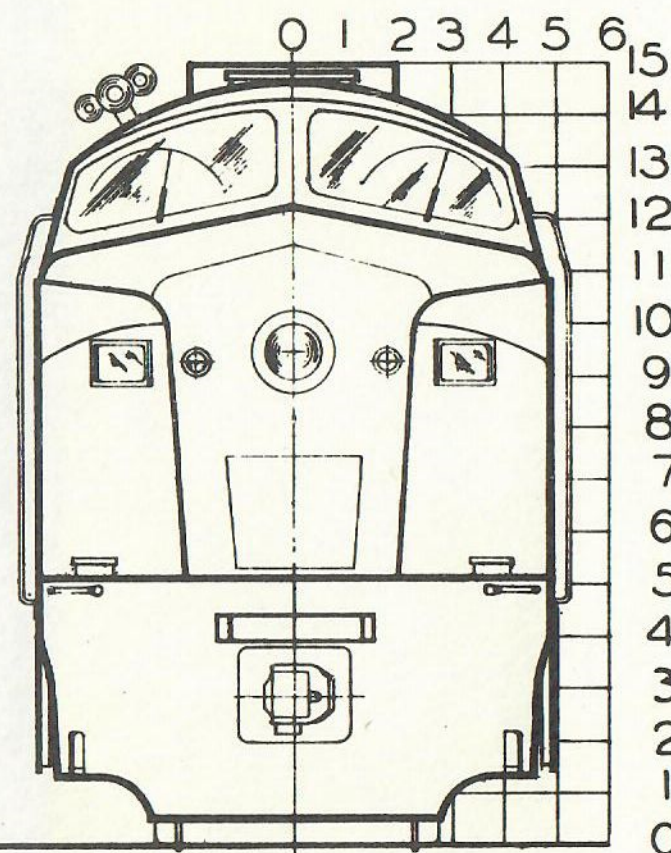
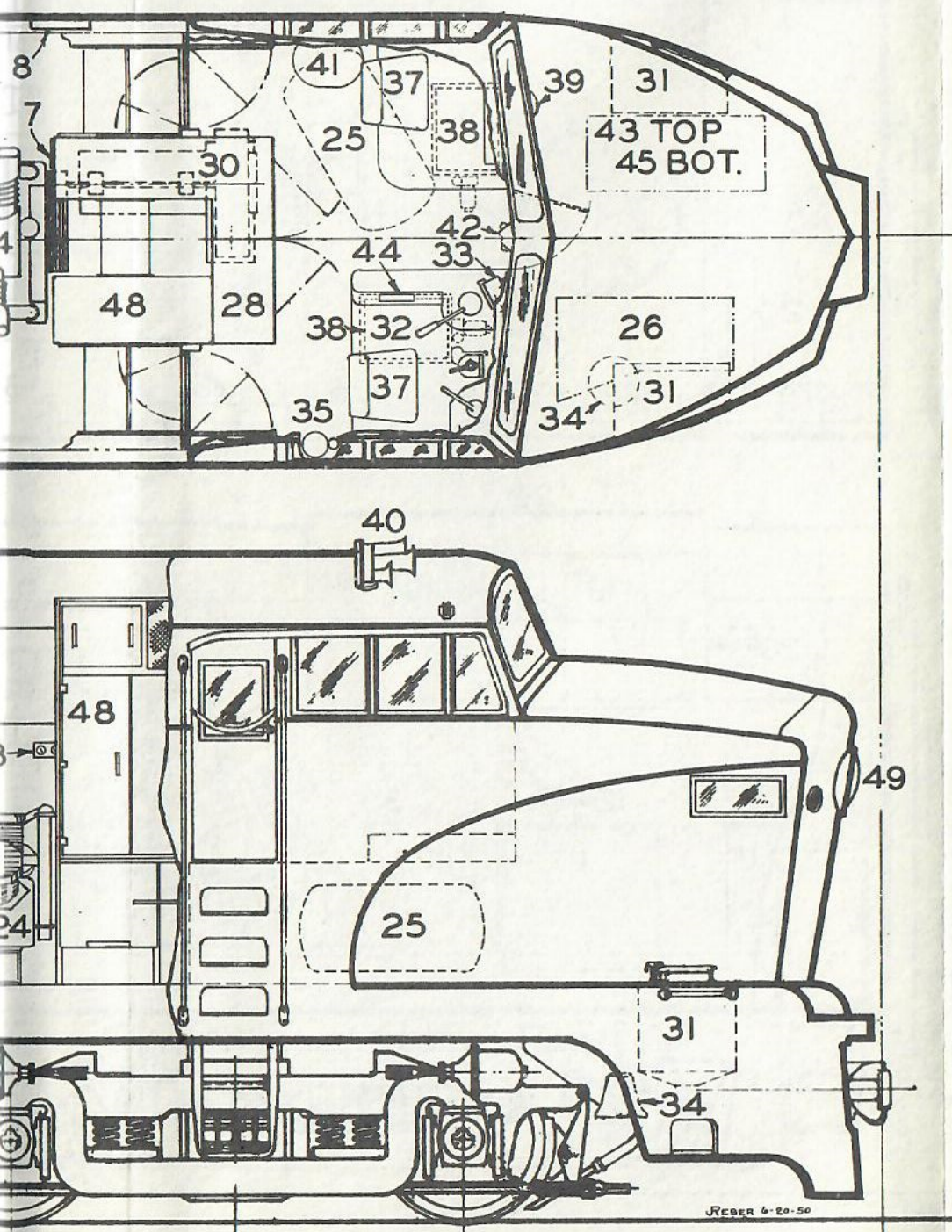
Bearings 7,380 Lbs.
Pair of Wheels and Gear on Axle
with Boxes 5,100 Lbs.
Diesel Engine with Turbocharger ... 38,500 Lbs.
Main Generator 13,200 Lbs.
Auxiliary Generator and Exciter ... 800 Lbs.
Diesel Engine Power Unit, Complete 52,500 Lbs.
Brake Air Compressor 1,300 Lbs.
Radiator Fan and Motor Assembly ... 1,150 Lbs.

SUPPLIES (per Unit)

Engine Cooling Water "A" Unit 300 Gal.
Engine Cooling Water "B" Unit 370 Gal.
Fuel Oil
"A" Unit 1,200 Gal.
"B" Unit 1,200 Gal.
Engine Lubricating Oil 190 Gal.
Air Compressor Lubricating Oil 7 Qts.
Sand 16 Cu. Ft.





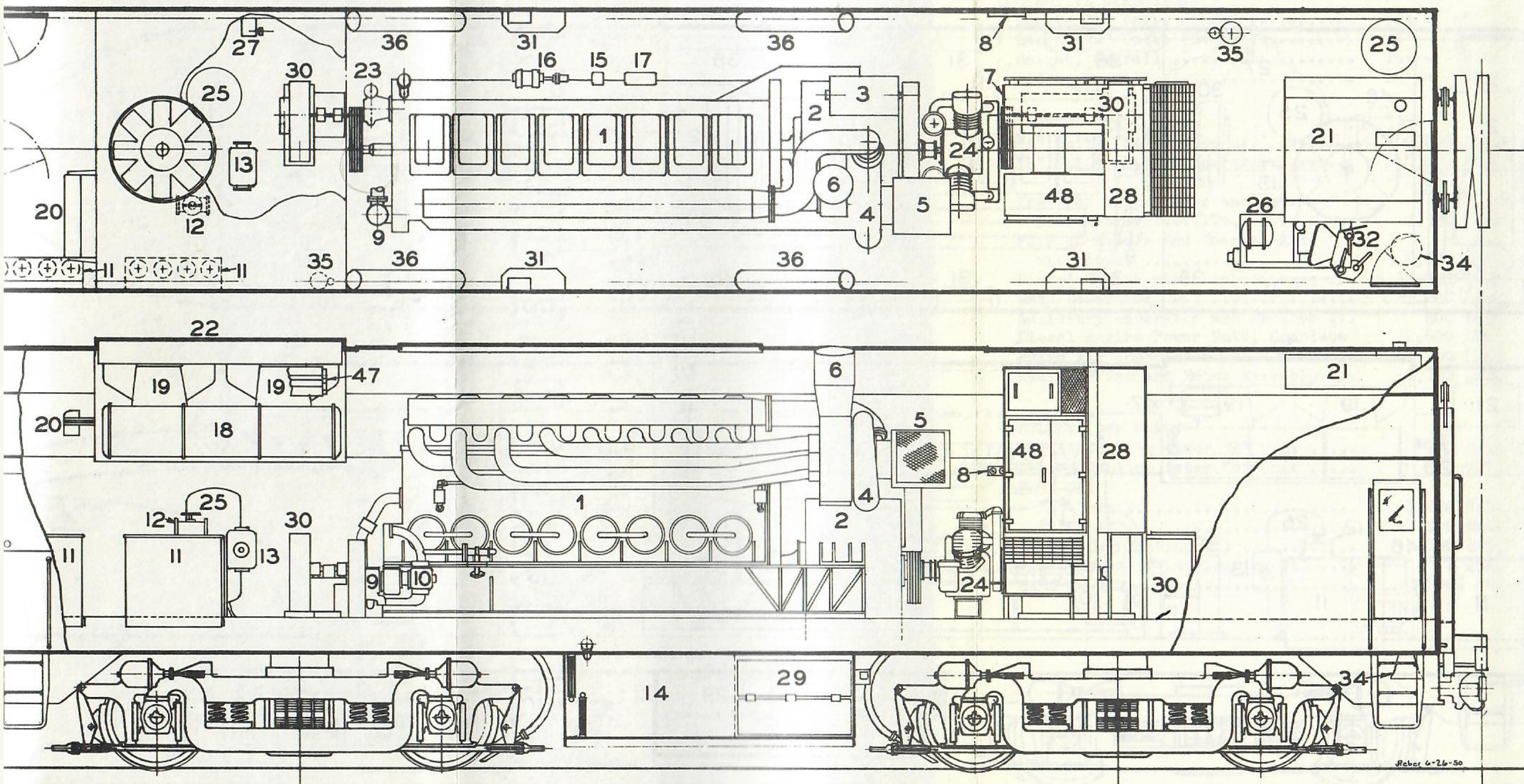


1. Engine
 2. Main Generator
 3. Auxiliary Generator & Exciter
 4. Turbocharger
 5. Air Intake Filter
 6. Diesel Engine Exhaust Stack
 7. Engine Control Panel
 8. Engine Control Gauges
 9. Lube Oil Suction Strainer
 10. Lube Oil Pump
 11. Lube Oil Filter
 12. Lube Oil Metal Edge Strainer
 13. Heat Exchanger - Lube Oil Cooler
 14. Fuel Oil Tank
 15. Fuel Suction Strainer
 16. Fuel Supply Pump
 17. Fuel Pressure Filter
 18. Radiators - Engine Cooling Water
 19. Radiator Fan with Motor
 20. Temperature Control Equipment
 21. Expansion Tank - Cooling Water
 22. Radiator Air Discharge
 23. Water Pump
 24. Air Compressor
 25. Air Reservoirs
 26. Air Brake Equipment
 27. Hand Brake
 28. Electrical Equipment Cabinet
 29. Storage Battery Box
 30. Traction Motor Blower
 31. Sand Box
 32. Operating Controls
 33. Speed Recorder*
 34. Bell
 35. Fire Extinguisher (Portable)
 36. Fire Extinguisher (Fixed) *
 37. Seat
 38. Cab Heater
 39. Alarm Bell
 40. Air Horn
 41. Water Cooler *
 42. Cab Signal *
 43. Cab Signal Equipment *
 44. Train Phone *
 45. Train Phone Equipment *
 46. Motor Generator Set *
 47. Dynamic Brake Resistors *
 48. Dynamic Brake Equipment *
 49. Headlight
 50. Toilet
- (* if installed)

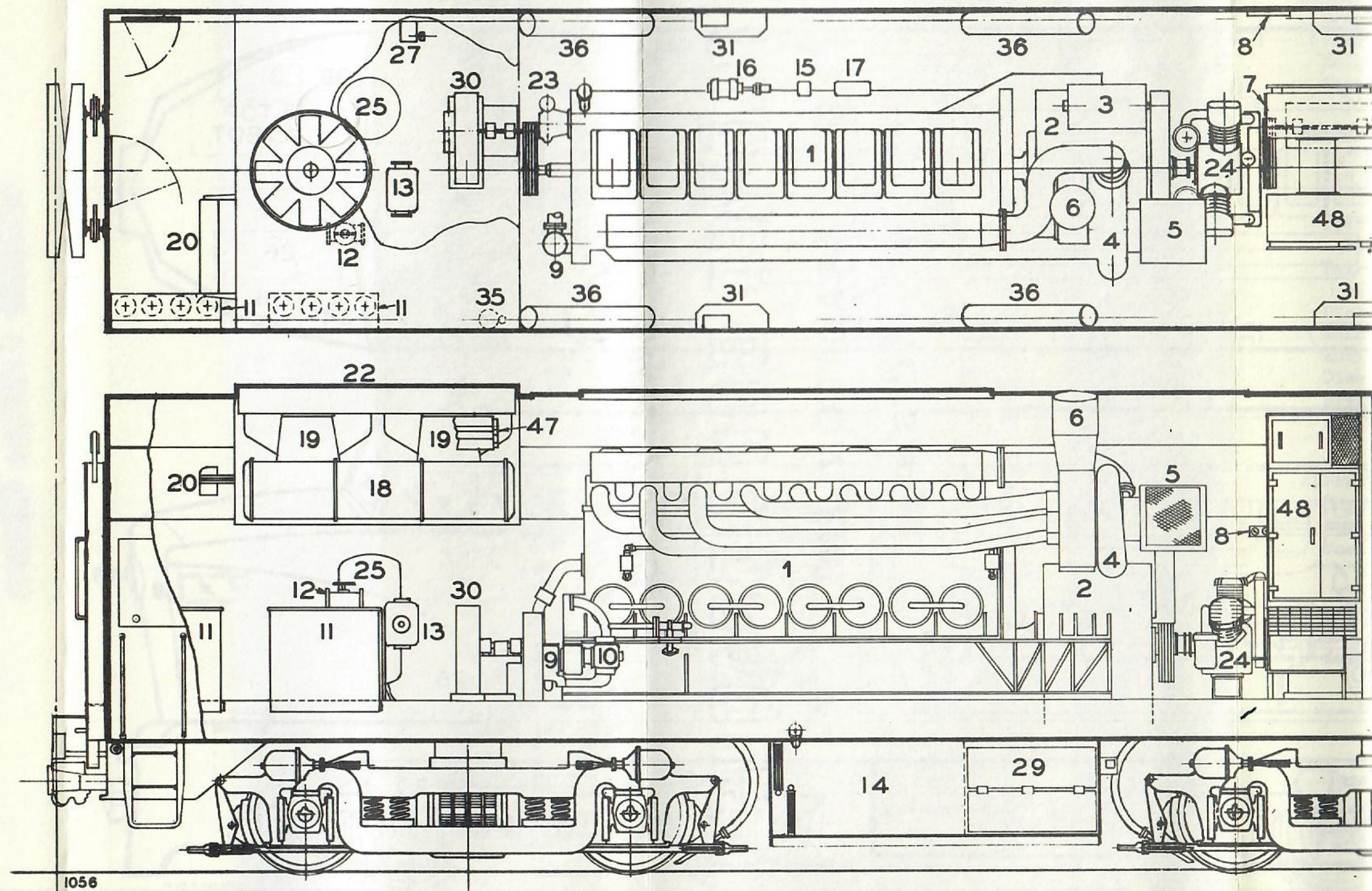
LOCOMOTIVE - ARRANGEMENT OF EQUIPMENT - "A" UNIT

Figure 1

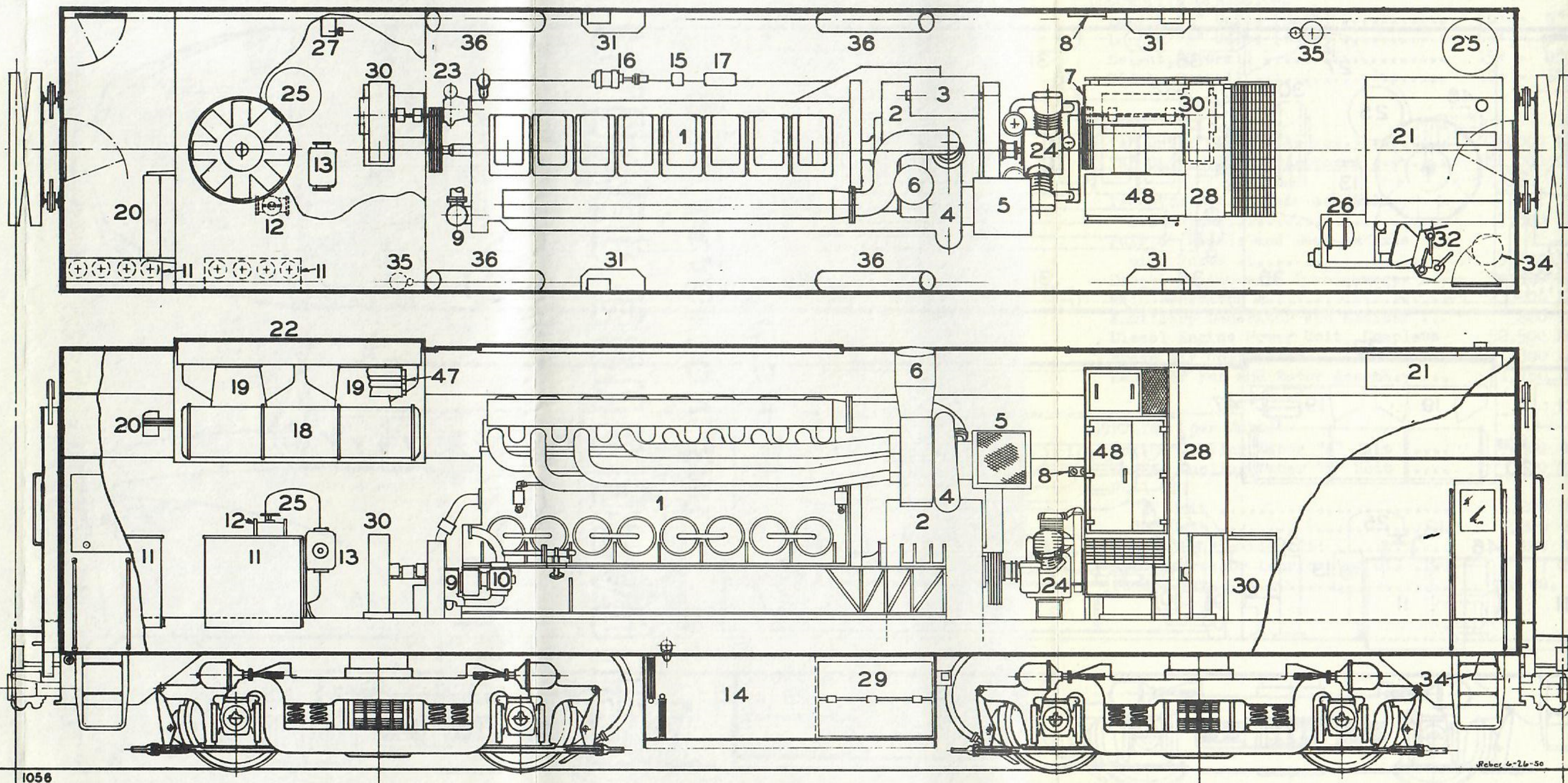
(See other side for "B" unit)



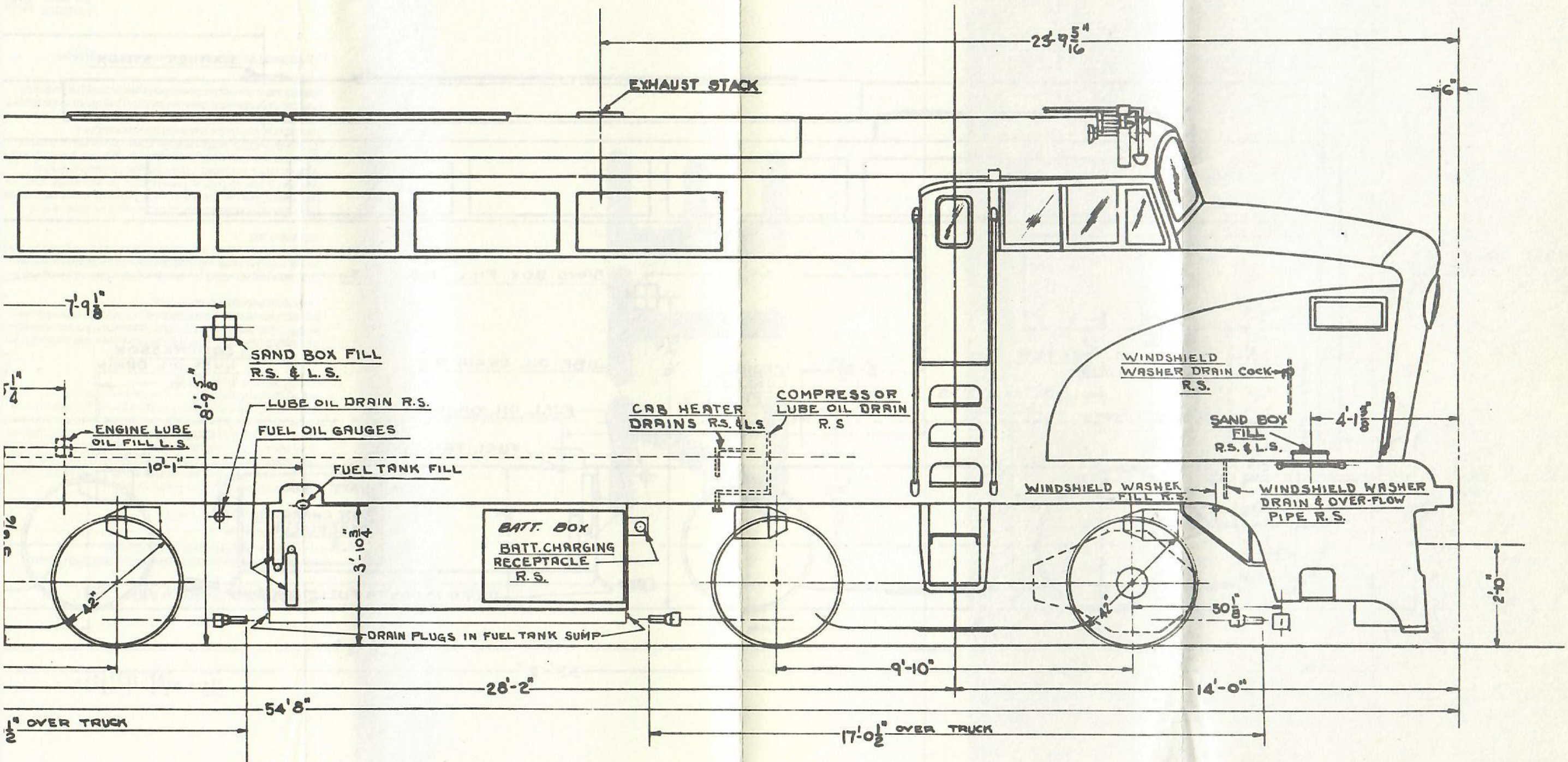
IVE - ARRANGEMENT OF EQUIPMENT - "B" UNIT



LOCOMOTIVE - ARRANGEMENT OF EQUIPMENT - "B" UNIT



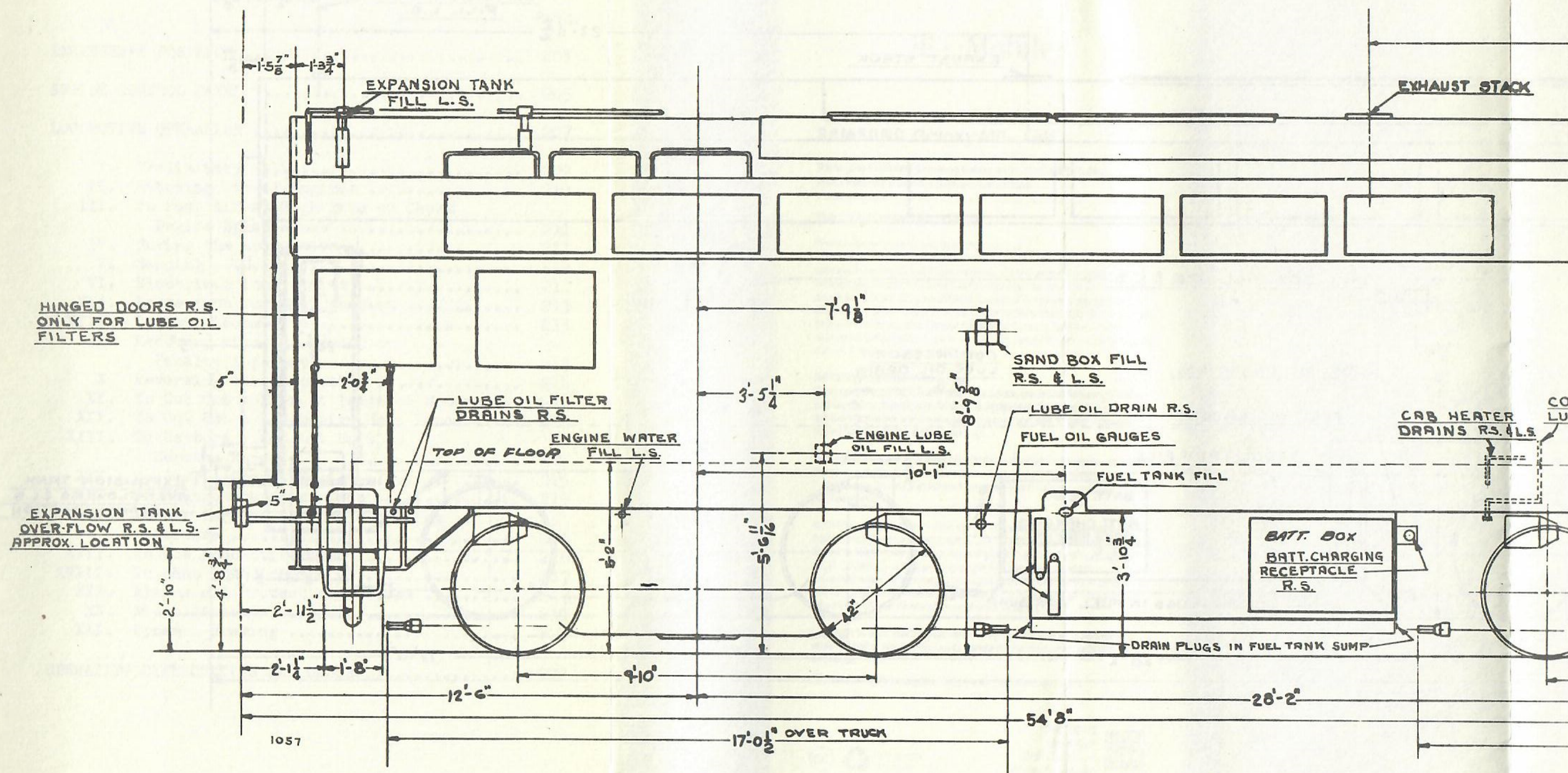
LOCOMOTIVE - ARRANGEMENT OF EQUIPMENT - "B" UNIT

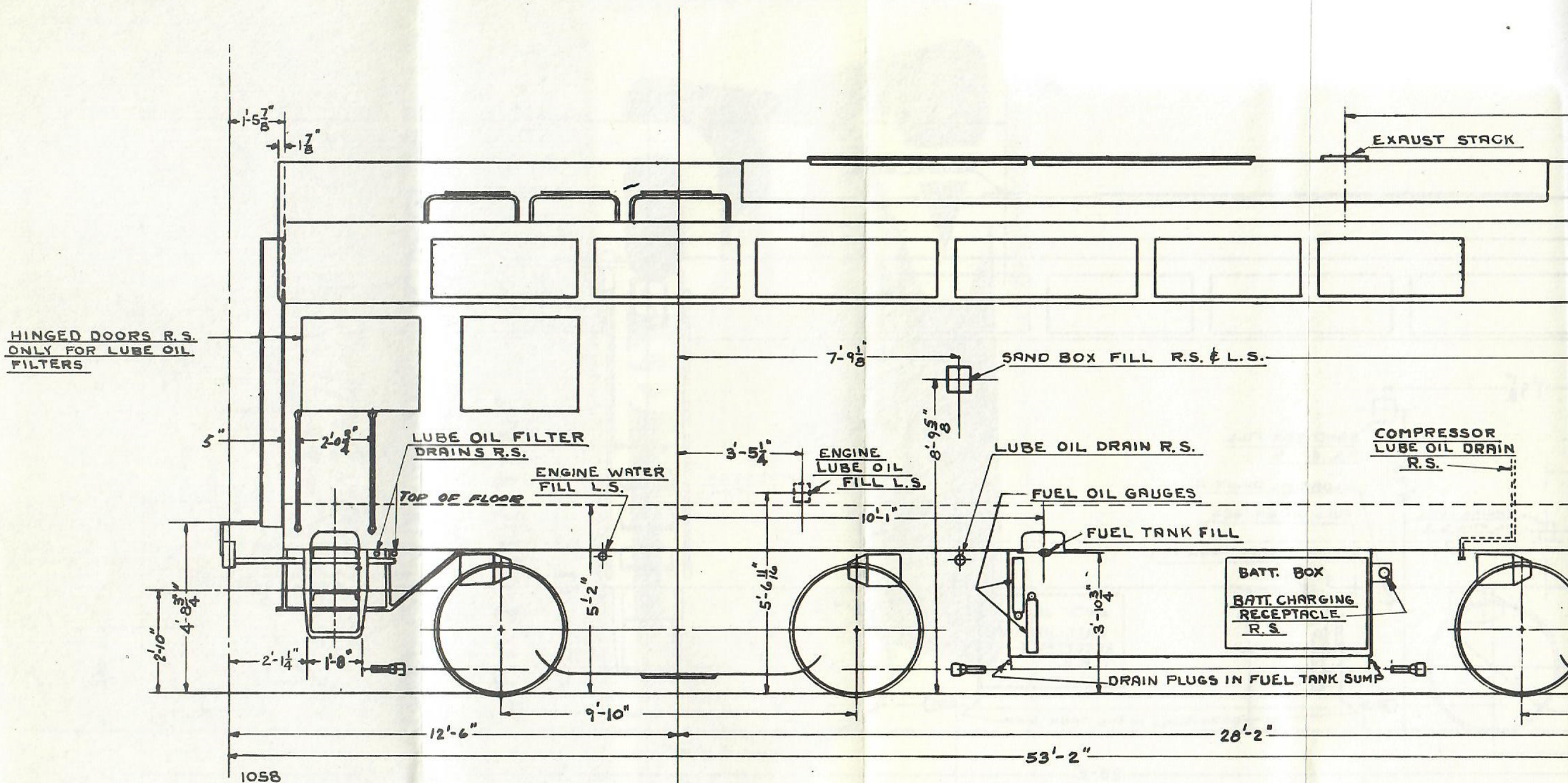


LOCOMOTIVE DIMENSIONS - LOCATION OF FILLS AND DRAINS - "A" UNIT

Figure 2

(See other side for "B" unit)



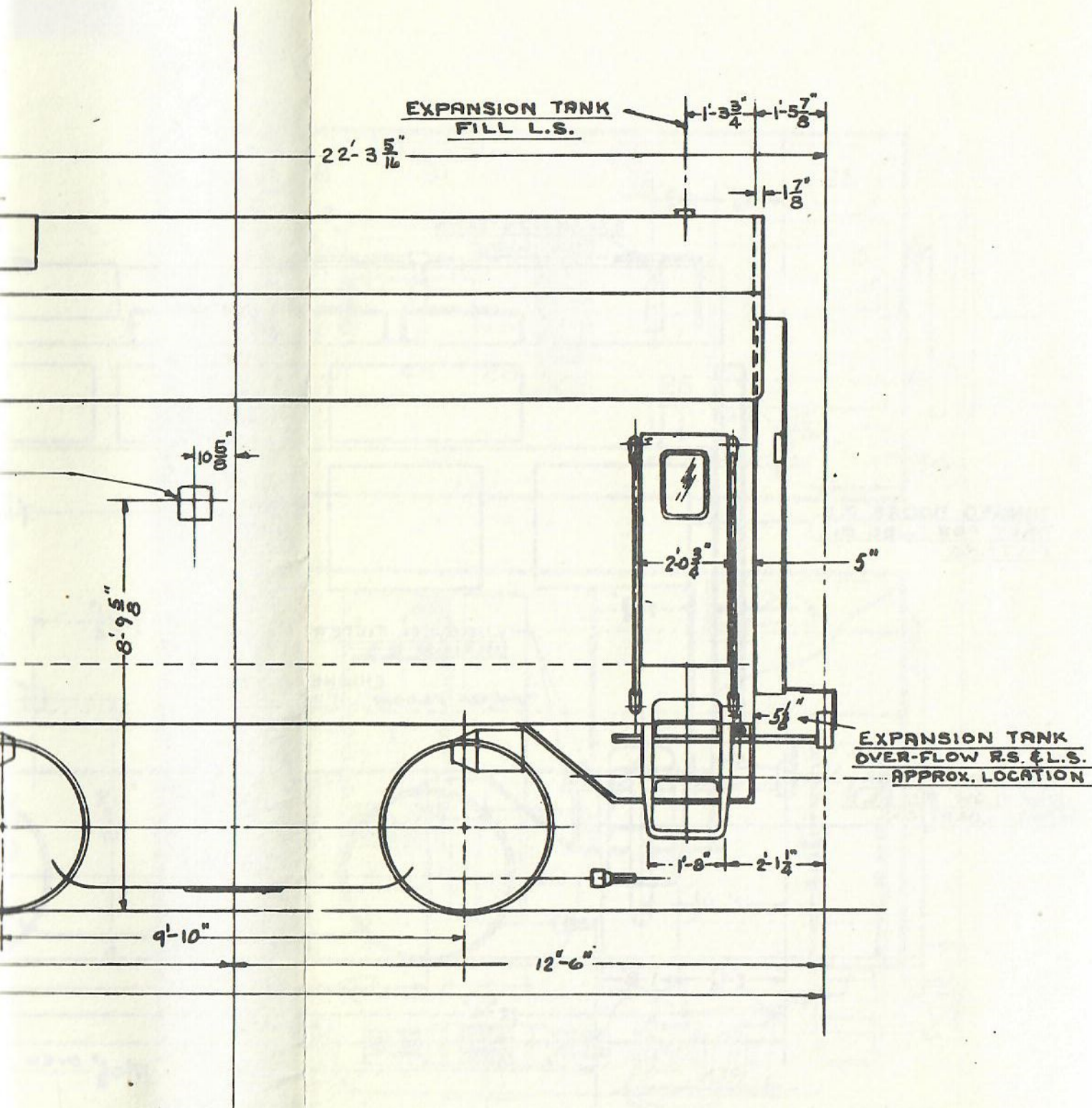


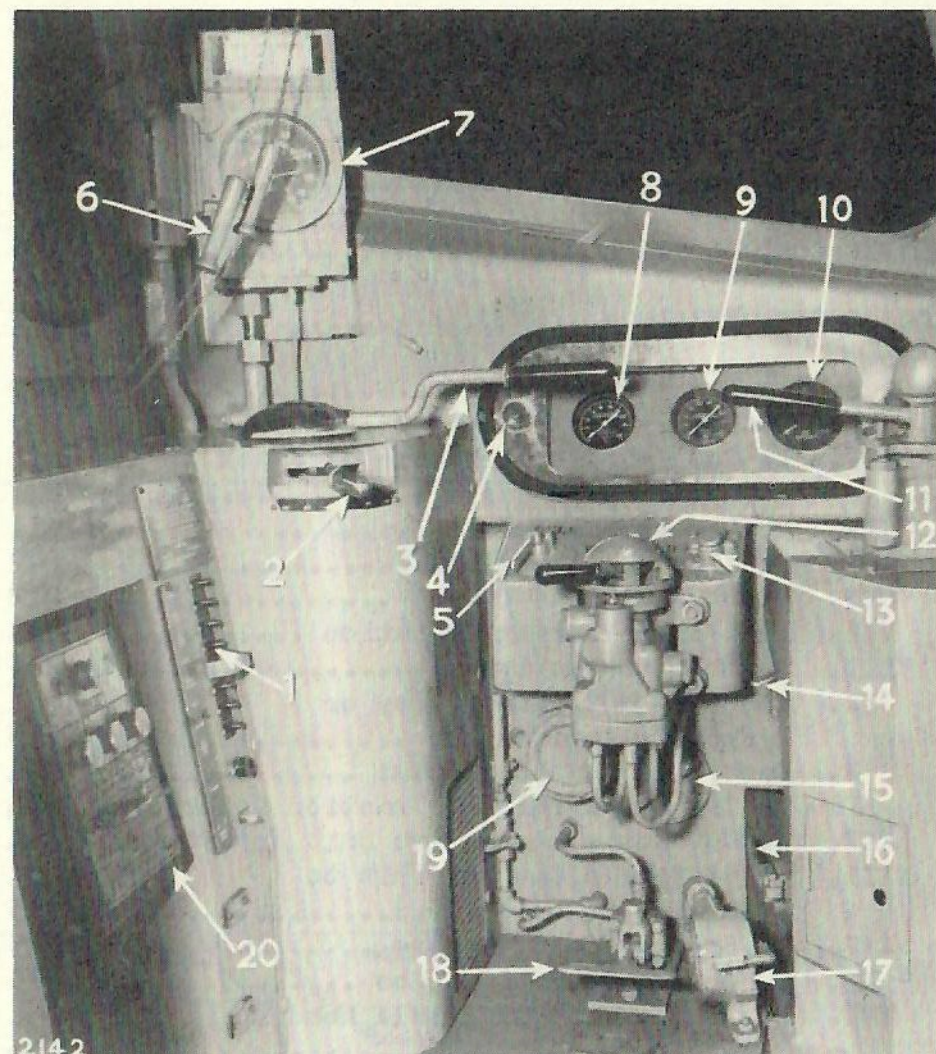
LOCOMOTIVE DIMENSIONS - LOCATION OF FILLS AND DRAINS - "B" UNIT

OPERATION

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ENGINEER'S POSITION
Figure 1

- | | |
|---|---|
| 1. Control Stand Switches | 12. Independent Brake |
| 2. Reverse Lever | 13. Sander (standard, or windshield if sanding bail is incorporated in #11) |
| 3. Throttle | 14. Selector Cock |
| 4. Indication Light | 15. Rotair Valve |
| 5. Bell Ringer | 16. Double Heading Cock |
| 6. Whistle Pull Cords | 17. Acknowledging Switch (if installed) |
| 7. Speed Recorder | 18. Dead Man Pedal |
| 8. Gauge - Brake Pipe and Cylinder Air Pressure | 19. Wheel Slip Buzzer |
| 9. Gauge - Main and Equalizing Reservoir Air Pressure | 20. Train Communication (if installed) |
| 10. Load Ammeter | |
| 11. Automatic Brake | |

ENGINEER'S POSITION

The instruments and controls in the engineer's cab are shown on the opposite page. The throttle, reverse lever and air brake equipment, which were mentioned in the general description, are familiar to operators of practically all types of motive power. In addition, the function of the following electrical equipment in the power circuits of diesel-electric locomotives should be understood by all operators.

Control Switch - The control switch beside the master controller must be closed to establish power control through the controller. Whenever it is closed, all other controllers in multiple are automatically interlocked out of action.

Emergency Engine Shutdown Switch - The shutdown switch on each control stand shuts down all engines in multiple, and is provided for emergency use in stopping engines. It will function from any unit in multiple, regardless of which unit is controlling.

Load Ammeter - The load ammeter on the engineer's instrument panel ("A" units) indicates the amount of current flowing through the traction motors. It is connected to motors No. 1 and No. 2 only, but an equal current normally flows through motors No. 3 and No. 4. The readings of this meter must be kept within allowable load limits, as posted in the cab.

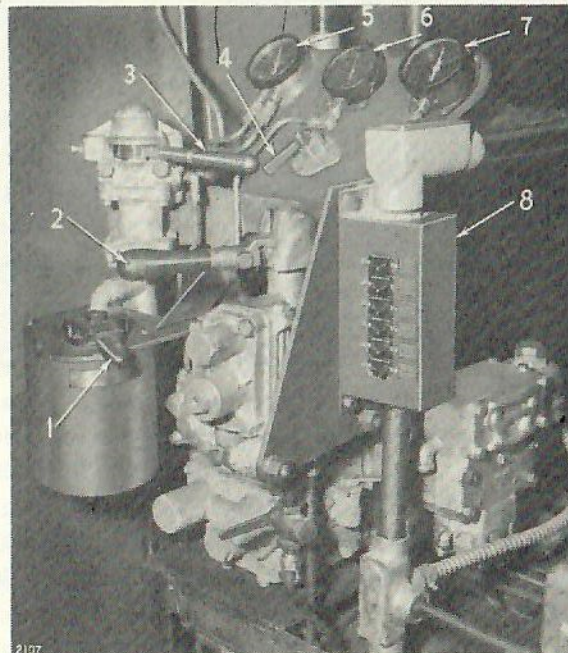
Wheel Slip Buzzer - The wheel slip buzzer on all units in multiple sounds when any wheels are slipping. Power on the slipping unit only is automatically reduced momentarily, and then increased to the original load. If the wheels continue to slip, the throttle should be retarded enough to eliminate slipping. Do not apply sand while wheels are slipping. Sanding is discussed under details of operation.

Deadman Foot Pedal - The deadman pedal is a safety device which, if released during operation, will automatically initiate a service application of the air brakes and bring the engines to idling speed. The engineer must keep the pedal depressed continuously while the locomotive is in operation.

Before the brakes are applied by this device, a warning whistle sounds. If the pedal is then depressed within 4 to 6 seconds, the application of the

brakes will be suppressed. To release controls for normal operation after a deadman pedal operation, depress the pedal, place the throttle in the off position, and move the automatic brake valve to the lap position until the application portion releases. Engines are kept at idling speed by an air interlock until the throttle has been returned to the off position.

Hostler's Controls - The instruments and controls for independent operation of the "B" unit, (when installed), are known as hostler's controls. This equipment, shown in the accompanying illustration, is located at the right side wall near the side entrance door. Many items used primarily in road operation are omitted from hostler's controls, such as the load ammeter, automatic brake valve, deadman pedal, sanding controls and switches for miscellaneous lights, heaters and accessories.



HOSTLER'S POSITION
Figure 2

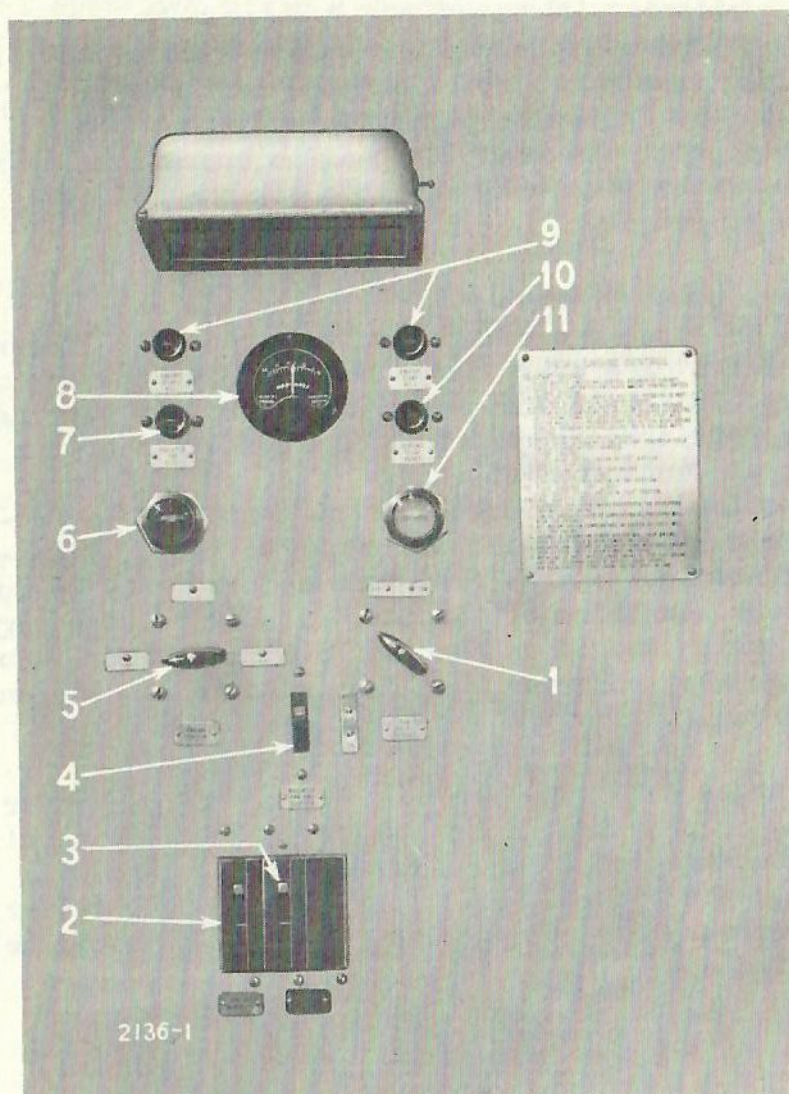
- | | |
|--------------------------------------|---|
| 1. Reverse Lever | 6. Brake Pipe and Cylinder Pressure Gauge |
| 2. Brake | 7. Control Air Pressure Gauge |
| 3. Throttle | 8. Control Switch Station |
| 4. Bell Ringer | |
| 5. Main Air Reservoir Pressure Gauge | |

ENGINE CONTROL PANEL

The control panel on the engine side of the electrical equipment cabinet along the left aisle, is shown on the following page. In addition to the switches which are used in specific operations as described later, the crew should check the following meters or gauges.

The battery ammeter, indicating the rate of charge or discharge of the battery, should be observed at least once every three hours. With the engine running, it should indicate either zero, or varying charge readings, depending on the condition of the battery. Continuous discharge of 10 to 15 amperes will not open the reverse current contactor (a protective device) but will drain the battery. Excessive continuous charge (about 50 amperes) may be due to a poor condition of the batteries or voltage regulator, which should be checked by a maintainer. Such readings when observed should be reported at the end of the run.

Gauges which indicate temperature of the water system, or pressure in the fuel oil, lubricating oil, or turbocharger oil lines, are mounted on the wall opposite the control panel. Any significant deviation from pressures as recommended on page 213 should be investigated.



ENGINE CONTROL PANEL

Figure 3

- | | |
|-------------------------------------|-------------------------------|
| 1. Fan Relay Cut-Out Switch | 6. Fan Warning Light |
| 2. Auxiliary Generator Field Switch | 7. Fan Relay Reset Button |
| 3. Ground Relay Cut-Out Switch | 8. Battery Ammeter |
| 4. Radiator Fan and Shutter Switch | 9. Engine Start Button |
| 5. Engine Control Switch | 10. Ground Relay Reset Button |
| | 11. Ground Indication Light |

LOCOMOTIVE OPERATION

All essential controls for the normal operation of the locomotive are summarized on the following page. More detailed information is given on subsequent pages. The instruments and controls used in operating the locomotive may be located by referring to the accompanying illustrations. The regularly used manual controls are located in the cab or on the engine control panel. Other manual controls are largely for emergency use, and are adequately described under their respective headings.

Units coupled together must have their pneumatic and electric systems properly connected. Under such conditions, the control circuits and emergency shut-down circuits from the control stand, and various indicating lights, audible indicators and automatic controls are train-lined to all locomotive units.

The engine of each unit is started at its adjacent engine control panel, after which routine operation is controlled from the cab.

The throttle increases or decreases the speed and power output of the engine by pneumatic action on the governor. The electrical connections of the throttle are arranged so that, in its off position, the power switches are opened and the traction motors are disconnected from the main generator.

The reverse lever, whose positions are marked, controls the pneumatically actuated reverser in the equipment cabinet. Turning the reverser changes the connections of the traction motor fields, which determines the direction of rotation, and therefore the direction of locomotive movement. If the locomotive is equipped for dynamic braking, the reverse lever on "A" units also controls a pneumatically actuated cam switch in the power circuits. A latch under the reverse lever must be tripped to move the lever to braking position.

SUMMARY OF OPERATING PROCEDURE

TO START DIESEL ENGINE

1. Close the battery switch and check that the control breaker in cabinet is closed.
2. Turn engine control switch (on control panel) to "idle" or "on" position. Leave the auxiliary generator field switch off.
3. Make sure that the throttle and reverse lever are in the "off" position.
4. Press engine start buttons firmly, until lube oil pressure reaches 20 pounds.
5. Then close auxiliary generator field switch.

TO OPERATE LOCOMOTIVE

1. Close control switch in cab on controlling unit only. Turn engine control switch (on control panel) to "on" in all units operating in multiple, if engines were started with this switch in "idle" position.
2. Check air pressures and perform brake test.
3. Make sure that fan and shutter switch is in "auto" position.
4. Move reverse lever to desired direction.
5. Depress deadman pedal and release brakes.
6. Advance throttle slowly to increase power, and retard throttle to reduce power.
7. When stopping, avoid electrical overload when applying brakes by reducing power first.
8. Come to full stop before reversing. Reverse lever is interlocked so it cannot be moved except when throttle is in its "off" position.
9. Keep ammeter within posted load limits.
10. Check gauge readings regularly.

TO SHUT DOWN LOCOMOTIVE

1. Shut down each power unit at its control panel.
 - a. Turn each engine control switch to "off".
 - b. Open each auxiliary generator field switch.
2. Open control switch at master controller.
3. Open battery switch in each equipment cabinet.
4. Set hand brake. Remove reverse lever and brake handles.

DETAILS OF OPERATION

I. PRELIMINARY

Adequate supplies and proper maintenance are necessary for satisfactory operation of the locomotive. Make sure that the locomotive is ready for operation by conducting the following routine inspections.

- A. Check for oil or water leaks. Leaks are more probable on a warm engine under pressure, and if observed under such conditions, should be reported. Check supplies.
 1. Fuel oil.
 2. Lubricating oil in engine crankcase.
 3. Lubricating oil in air compressor crankcase.
 4. Oil level in engine governor.
 5. Engine cooling water.
 6. Sand.
- B. Check that condensate is drained from the air reservoirs.
- C. Turn on lights if necessary. Cab, cabinet and engine room lights are fed from the battery through a circuit breaker located in the equipment cabinet. This breaker is normally closed. Most other lights will burn only when the battery switch, in addition to their individual switches, is closed.
- D. Check that the following switches in the electrical equipment cabinet are in their normally "on" or closed position.
 1. Control breaker.
 2. Traction motor cut-out switch.
 3. Auxiliary generator power breaker.
 4. Fan motor breaker.
 5. Cab heater fan breaker.
 6. Dynamic braking cut-out switch (if installed).
 7. Fan differential cut-out switch (if installed).
- E. Check that all trailing units are properly connected.
 1. Electrical train-line jumpers must be in place.
 2. Brake piping must be properly train-lined through the end connections.
 3. Close "B" unit cut-out cocks on hostler's brake valve, and on brake pipe feed valve. Check

- that all dead engine cocks are in live position.
4. Remove handles of brake valves and the reverse lever from trailing units.
 5. Set the Rotair Valve as follows:

Type K-2: On trailing "A" units, set the valve in Lap for any and all settings of the valve in the leading "A" unit. There is no need to do anything on trailing "B" units, because the Controlled Emergency Pipe is train-lined.

Type K-2-A: On trailing "A" units, set the valve in the same position as on the leading "A" unit. On trailing "B" units, set the Controlled Emergency Cutoff Cock (portion) to Passenger, Lap, or Freight, according to the position of the valve on the leading "A" unit.

II. STARTING ENGINES

Before starting engines, make sure that outside battery charging receptacle is disconnected. Start each engine independently from its adjacent control panel.

NOTE: If it is ever necessary to start an engine from an outside source of power, be sure the outside circuit is able to carry the heavy current involved.

1. Check that throttle and reverse lever are in their off position and that emergency shutdown switch at the control stand is not closed.
2. Close battery cutout switch in the equipment cabinet.
3. The control panel switches must be set as follows:
 - a. Auxiliary generator field switch - Off.
 - b. Radiator fan and shutter switch - Auto.
 - c. Ground relay cutout switch - On (normally).
 - d. Engine control switch - On or Idle. Fuel pressure gauge should read at least 20 lbs.
4. Press No. 1 engine start button. If necessary to crank faster, press No. 2 start button, keeping No. 1 button in. Press firmly until lube oil pressure reaches 20 pounds. If the button is released before pressure reaches 20 pounds, oil pressure switch will automatically stop the engine. CAUTION: If engine does not turn, release start button immediately. Should engine fail to fire within 10 seconds, release start button and determine the reason. See Operating Difficulties.
5. Place auxiliary generator field switch in the

"on" position. This should charge the battery.

Upon starting, battery charging ammeter will register current between 5 and 50 amperes. Reading will approach zero as batteries become fully charged.

III. TO PUMP AIR AT HIGH RATE OR CHECK ENGINE SPEED RANGE

With the locomotive at standstill, or coasting down grade, the diesel engine can be operated above idling speed for the purpose of pumping air at a high rate. With the control switch closed, and the reverse lever off, advance the throttle slowly until required pumping rate is reached. The engine speed will increase after the throttle has advanced about 40° from the off position. The engine speed is similarly increased for checking the engine speed range or making an engine load test.

IV. MOVING THE LOCOMOTIVE

A. Before starting, inspect the locomotive as follows:

1. Check oil pressure gauge readings.
2. The engine cooling water temperature should be between 145° and 165° on an idling engine.
3. Air pressure should be 140 pounds in main reservoir, and 70 pounds in the control system.
4. Check both automatic and independent brake valve application and release.
5. Release hand brakes.
6. Test horn, bell ringer, sander and windshield wipers.
7. Radiator fans and shutters should operate properly. Non-automatic operation, which is described later, should be reserved for emergency.
8. The traction motor blowers should be operating properly. A LOCOMOTIVE MUST NOT HAUL A TRAIN UNLESS TRACTION MOTORS ARE ADEQUATELY COOLED.
9. Engine control switch must be On (if engine was started in Idle, or subsequently isolated).

- B. Close control switch and move reverse lever to the forward or reverse position, depending on the desired direction of travel.
- C. Place foot on deadman pedal. Release air brakes.
- D. Move throttle to first notch and hold until load ammeter indicates a flow of current. It takes about four seconds for the power circuits to close.
- E. When the ammeter registers current, slowly advance the throttle to handle the train smoothly, and keep the current within allowable load limits.

- F. Four steps of field shunting occur automatically as locomotive speed increases. There is no transition of power circuits, and manual control of power is exercised entirely through the throttle.
- G. Retard the throttle to reduce power when stopping, slowing down, or eliminating wheel slip. Avoid wheel slip if possible.
- H. If wheel slip occurs, buzzer will sound, and power will automatically decrease until slipping stops. Power is then automatically restored. If wheel slip recurs, retard throttle. Do not apply sand.

NOTE: To operate a "B" unit independently, when hostler's controls are installed, start the engine, close the control switch, release the independent brake and use the reverse lever and throttle in the same manner as outlined for "A" units.

V. SANDING

DO NOT APPLY SAND WHILE THE WHEELS ARE SLIPPING

Sand is a preventive, not a corrective measure. Always use sand sparingly. The even starting torque of the diesel electric locomotive makes the use of sand seldom necessary. The flow of sand through the sand nozzles is controlled by magnet valves which are connected electrically to a sander switch. The sander switch (on "A" units only) is air operated by the sanding lever in front of the engineer, (or, as a modification, by a sanding bail on the brake pedestal). The magnet valves are electrically interlocked with the controller so that sand is automatically applied to the leading wheels only.

During an emergency brake or overspeed governor application, the sander valve is actuated automatically, and sand is applied to the same wheels as in hand sanding.

VI. ELECTRICAL LOAD LIMITS

The locomotive may be operated for an indefinite time at loads within the continuous rating. Any reading of the load ammeter in excess of the continuous rating constitutes an overload. Electrical apparatus will safely carry an overload for a limited time if maximum allowable temperature has not been reached. Overheating due to excessive loads can result in serious damage to the equipment which may not be apparent immediately, but can cause failure later on. A table of allowable load limits under full cooling (i.e., full

engine speed) is posted in front of the engineer. ENGINEERS SHOULD ALWAYS KEEP WITHIN POSTED LOAD LIMITS. When the time limit is reached for any overload, no overload capacity exists at any other amperage above continuous rating. The engine must then be idled to cool the electrical equipment unless the train can continue at full engine speed at or below the continuous rating.

VII. INSPECTIONS DURING OPERATION

- A. Check gauges frequently. Investigate and report any great deviation from normal.
 - 1. Lubricating oil pressure, engine - normal 50 to 55 pounds at the gauge at full engine speed when normal operating temperature has been reached.
 - 2. Lubricating oil pressure, turbocharger - Normal 22 to 25 pounds at full engine speed.
 - 3. Fuel oil pressure - Normal 25 pounds.
 - 4. Control air pressure - Normal 70 pounds.
 - 5. Water temperature - A range of 145° to 190° is automatically maintained by the fan and shutter controls. If water is too hot, engine will run only at idling speed. Try fan and shutter switch in the "on" position.
- B. Check battery ammeter. It should not show a discharge when engine is running. See page 205.

VIII. TO STOP LOCOMOTIVE

- A. Normal stop - Move the throttle gradually to first running position and hold it there until load ammeter indicates that the current has dropped. Then move the throttle off, and apply the brakes in regular service application. Release deadman only after independent 30# brake cylinder pressure applies.
- B. Emergency stop - Move the automatic brake valve to emergency position. The power units are automatically idled and disconnected from the motors.

IX. RECOVERY AFTER EMERGENCY, OR PENALTY, APPLICATION

- A. To resume normal operation after any emergency, deadman, speed control, train control, or similar extra-ordinary brake application:
 - 1. Depress deadman pedal.
 - 2. Move throttle to the off position. An air interlock keeps the engines idling until throttle is off.
 - 3. Place automatic brake valve in Lap position until brake application portion releases.

X. REVERSING THE LOCOMOTIVE

- A. CAUTION: Do not move the reverse lever while the locomotive is still in motion. Do not drift in one direction with the reverse lever set in the opposite direction. Serious damage to electrical equipment may result if this rule is disregarded.
- B. To reverse the locomotive:
1. Move the throttle to the off position.
 2. Apply brakes to come to full stop.
 3. Change reverse lever to the opposite direction.
 4. Release brakes and advance throttle in the normal manner.

XI. TO CUTOUT A PAIR OF TRACTION MOTORS

If a failure occurs in a traction motor, it may be taken out of service by means of the traction motor cutout switch in the electrical equipment cabinet. The nameplate on the switch clearly designates the motor connections for its various positions.

- A. Move the engine control switch on the engine control panel on the affected unit to the "idle" position, to take the load off the motor. THE TRACTION MOTORS SHOULD NOT BE CUT OUT UNDER LOAD.
- B. Set the traction motor cutout switch to cut out the defective motor. (A pair of motors is generally in each circuit, and therefore are cut out together.)
- C. The load ammeter is connected to register the flow of current through motors 1 and 2, consequently there will be no ammeter reading if this pair is cut out, even though power is being supplied to the other motors. The ammeter reading will not be affected if motors 3 and 4 are cut out.

XII. TO CUT OUT A LOCOMOTIVE UNIT ENROUTE

- A. In event of electrical failure enroute, a locomotive unit can be cut out electrically by isolating it. An isolated unit will have power to pump air, charge batteries, and operate the engine water system to prevent freezing in cold weather.
1. To isolate a unit, place the engine control switch on the control panel in the "idle" position, which reduces engine speed to idling and opens the motor circuits.

- B. If the trouble is mechanical, the unit can be shut down entirely and towed until a terminal is reached, or a relief unit obtained. Stop the engine as in XIV below, and set brake system as in XVII, Towing, on a subsequent page.

A unit may be isolated or shutdown while other units in multiple are working under advanced throttle.

XIII. TO RESTORE A CUT OUT UNIT TO SERVICE ENROUTE

After correcting trouble, a power unit may be put back into service ("back on the line") as follows:

- A. If the unit is isolated, place the engine control switch in the "on" position.
- B. If the engine is shut down, check that the engine control switch is in the idle position, and then start the engine in the usual manner. Then place the engine control switch in the "on" position.

XIV. TO STOP A DIESEL ENGINE

- A. The engine of any one unit is NORMALLY stopped by placing the following switches on the control panel in their "off" position.
1. Engine control switch.
 2. Auxiliary generator field switch.
- B. To stop ALL engines in an EMERGENCY:
1. Close the emergency engine shutdown switch on the control station beside the master controller on any "A" or "B" unit.

XV. TO CHANGE OPERATING CABS

- A. Cut out the cab which has been controlling.
1. Make a full service reduction with the automatic brake valve.
 2. Place automatic brake valve in lap position and independent brake valve in release position.
 3. Place double heading cock in closed (cut out) position.
 4. Move K-2-A Rotair Valve to Pass Lap, or Frt Lap, as required, (or K-2 valve to Lap).
 5. Place automatic brake valve in running position and remove both automatic and independent brake valve handles.

6. Open control switch beside master controller, and remove reverse lever.

B. Cut in the cab which will be controlling.

1. Place Rotair Valve in Pass or Frt, as required.
2. Insert brake valve handles, place independent brake valve in full application position, and open double heading cock.
3. Close control switch. Insert reverse lever.
4. Make brake test.

XVI. PUSHER SERVICE OR DOUBLE HEADING SERVICE

In such service, power is controlled on each locomotive independently in the usual manner, but service brakes are controlled by the leading locomotive only. However, brake pipes can be set so that the non-controlling locomotive can release its own brakes only, to avoid sliding or over-heating the wheels. Conform to the standard practice of your road. With 24-RL brake equipment, place the Rotair Valve in Pass or Frt, depending on the service required, place dead engine cock in live position, and close double heading cock. Place automatic brake valve in Running position and independent brake valve in Release position.

XVII. TO TOW LOCOMOTIVE UNIT

When a unit is to be moved by an outside source of power, either as a dead-head unit in a train, or as a shutdown unit of the operating locomotive, the brake system should be set so it operates like the cars of a train. Instructions of the air brake manufacturer should be studied for the specific type of equipment involved. In general, for type 24-RL equipment, proceed as follows.

- A. Shut down the engine, open the battery switch, place throttle and reverse lever off, and remove reverse lever.

B. Set "A" and "B" unit air lines as follows:

For "A" units.

1. Place automatic and independent brake valves in running and release positions respectively, and remove handles.
2. Close double heading cock.
3. Set dead engine cock in dead (open) position.
4. Turn Rotair Valve to Pass position.
5. Open brake pipe branch pipe cutout cock to D-24 control valve.

For "B" units.

1. Open dead engine outout cock on D-24 control valve and brake pipe branch pipe cutout cock.
2. If controlled emergency cutoff cock (portion) is used, place in passenger position. (This is on units equipped to multiple with K-2-A Rotair Valve in the "A" unit.)
3. Close the cutout cock to the brake pipe reducing valve.
4. Open the cutout cock and remove the plug from the alternate connection opposite the air hose, at one end of each unit, in the Actuating, Independent-Application-and-Release, and (when used) the Straight Air pipes, to insure a release of the automatic brake by affording an atmospheric opening from these pipes.
5. If equipped with hostler's controls, remove the independent brake valve handle (running position), and open the cutout cock in the Independent Application and Release pipe, under the independent brake valve.

XVIII. TO SHUT DOWN LOCOMOTIVE

- A. Make sure the brakes are properly set, applying independent brake and hand brake as required. If units are customarily left in readiness for moving by another locomotive with air hose connected, close brake pipe cutout valve on automatic brake pedestal.
- B. Remove reverse lever from master controller.
- C. Stop engines as previously directed, open control switch beside master controller (if closed), and open battery switch in electrical equipment cabinet.

Note 1. Yard movements usually involve idling prior to shutdown. However, if engines are quite hot, idle them for about ten minutes to dissipate heat.

Note 2. In freezing weather, protect engine cooling system. If locomotive is left unattended with engine running, remove reverse lever and set brakes.

XIX. ALARMS AND PROTECTIVE DEVICES

An alarm system rings a bell on all units in multiple when an engine shuts down, a water temperature switch closes, or a ground relay picks up. Other devices (when installed) may be connected to the bells,

such as a fan relay or a stack switch in the engine exhaust. An attendant-call circuit is connected to the regular alarm bell. Lights may be connected with the alarm to give visual indications.

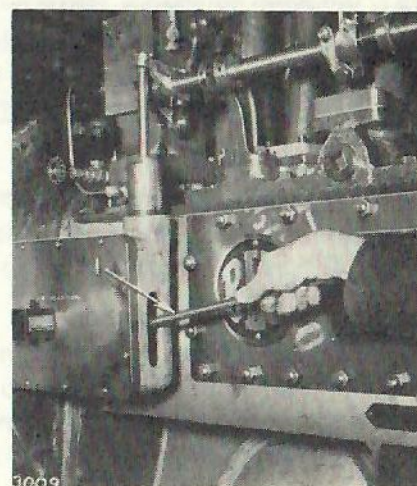
The engine shutdown indication is received through an alarm relay which is connected in parallel with an engine shutdown magnet valve. The valve and relay are fed through the lube oil pressure switch which must be closed to maintain fuel supply. If the switch opens due to low lube oil pressure, or any engine stoppage, the alarm relay closes and operates the alarm.

The water temperature switch is closed by hot engine water. It idles the engine and sounds the alarm. It is not regularly connected to an indicator light.

The ground relay and fan relay idle the engine, and in addition, cause indicator lights to burn on the engine control panel of the faulty unit only. The crew can thereby quickly determine which unit is defective. A unit should be isolated (cut out) unless alternative operation is understood and permitted by your operating regulations. Details of these relays are given later.

Separate alarms may be installed in connection with special equipment (such as dynamic braking, fire, train speed control, etc.), and are described in separate paragraphs for such equipment. The principal standard protective devices which are not connected to the alarm are as follows:

An engine overspeed stop is provided to protect the engine against excessive speed. It is a spring loaded tripping device situated on the front of the camshaft casing at the generator end of the engine. It is gear driven from the camshaft and is set to trip at a predetermined camshaft speed. The tripping operation actuates a plunger which moves the fuel control shaft to the no-fuel position and stops the engine. Before starting the engine again, the overspeed stop must be reset. Insert bar in housing and pull down.



RESETTING
OVERSPEED STOP

Figure 4

1. RESET BAR
Pull down to
reset overspeed stop

An emergency fuel cut-off valve is provided in the main suction line to the motor driven supply pumps. In case of fire or other emergency it may be closed to shut off the fuel supply. It is closed manually by pulling the pull-rings in the cab, or outside the locomotive. Each unit is shut off independently. When this valve has been tripped, it must be reset manually to restore the fuel supply. It may be necessary to bleed air from the fuel line. Be sure the controls have been returned to their "off" position before starting the engine.

XX. MISCELLANEOUS

RUNNING THROUGH WATER

Care must be taken not to allow the traction motors to come in contact with water unnecessarily. In case of unavoidable operation of the locomotive over water covered track, the speed should be reduced. The locomotive should not be operated through water having a depth of more than three inches above the top of the rail.

OPERATING OVER CROSS-OVERS

The throttle should be retarded about a car's length ahead of a cross-over to avoid excessive jar on gear teeth and to prevent pitting of commutators, which would be the result were the locomotive to be operated over cross-overs at full normal current.

INCIDENTAL REVERSING MOVEMENTS

The reverse lever of a live locomotive should always be set in the direction of travel, when drifting backward against slack, or when being moved by another locomotive. In many instances a neutral position would be sufficient. However, every precaution should be taken to insure that, during such movements, an application of power cannot be made in the opposite direction. Avoid drifting backward when starting up a grade.

WATER TEMPERATURE CONTROL

Electrically driven radiator fans are automatically regulated by a thermostatically operated temperature controller when the fan and shutter switch is in the "auto" position. If the automatic system does not function properly, make sure that the fan circuit

breaker in the equipment cabinet has not opened. If the system does not function with this switch closed, by-pass the automatic controls by throwing the fan and shutter switch to the "on" position. Fans will then run at intermediate speed.

RERAILING LOCOMOTIVE

Do not apply power to derailed driving wheels. A traction motor will be seriously damaged if power is applied without a load, as is the case when wheels spin freely. Isolate the unit by turning the engine control switch to "idle" and push with the other units. If a pusher unit is not available, as for example a single unit being derailed in yard movement, set the traction motor cut-out switch to disconnect the motors of the derailed wheels. Power may then be applied through the remaining motors.

XXI. DYNAMIC BRAKING

Dynamic braking when installed supplements the standard air brake equipment. Its use, particularly on long, descending grades, serves to reduce wear on brake shoes and prevents the excessive heating of wheels which would occur with constant application of train air brakes. Dynamic braking is controlled by the throttle and reverse lever. It is independent of the air brake system, although both systems may be used simultaneously on the cars of the train if necessary. However, the two braking systems are interlocked to prevent their application at the same time on the locomotive. Dynamic braking necessarily bunches the train, and slack should always be adjusted gradually.

The maximum speed at which dynamic braking is practical is about 60 miles per hour. Above 60 mph use the air brakes only. As the dynamic braking effort fades out at low speed, use the automatic air brakes, as necessary. Avoid a quick run-out of the head end whenever regular operation is resumed.

Dynamic braking will not function on any unit whose fan circuit is defective or whose fan-differential relay cut-out switch is in the "off" position. This switch is always left "on" except in emergency.

A. To apply dynamic braking:

1. Move throttle to the "off" position.
2. Move reverse lever to "DYNAMIC BRAKING" position. (Trip a small latch under the lever to release it).
3. Advance throttle to first notch.
4. After a few seconds, when load ammeter shows a dynamic braking current, advance throttle gradually to increase braking effort.
5. LOAD AMMETER SHOULD NOT EXCEED BRAKING LIMIT.
6. To decrease braking effort, retard throttle.
7. To resume normal operation:
 - a. Move throttle to "off" position.
 - b. Move reverse lever to "for" position. Allow a few seconds for circuit to change-over.
 - c. Adjust slack gradually, then apply power as desired.

A dynamic braking overload light on the engine control panel gives a warning when the load limit in item 5 above is exceeded. The operator should retard the throttle to reduce the load. Supplement the dynamic brakes with applications of train air brakes if necessary. (A limit relay changes the field to reduce the braking effort. This is normally sufficient to prevent the overload light from coming on). If the fan light is on, and cannot be extinguished by pressing the fan reset button, air brakes must be used exclusively. Further details about the shutter controls and electrical controls are given in the Electrical Section of this book.

In step 6 above, do not retard the throttle below the first notch above idle, if braking is to continue, because braking circuits and dynamic brake interlock are broken in the idle position, and steps 3 and 4 must be repeated if braking is resumed under such conditions.

OPERATING DIFFICULTIES

AND CAUSES

ENGINE FAILS TO TURN WHEN ATTEMPT IS MADE TO START

1. Battery switch open.
2. Emergency engine shutdown switch on control switch station may be closed.
3. Engine control switch may be "off".
4. Control breaker (35 amp. in cabinet) open.
5. Starting contactors may be stuck open.

ENGINE TURNS BUT WILL NOT FIRE OR IT WILL NOT CONTINUE TO RUN AFTER RELEASING THE START BUTTON

1. Fuel tank empty.
2. Emergency fuel shut off valve has been tripped.
3. Engine overspeed stop has been tripped.
4. Clogged fuel filter or strainer.
5. Fuel system not primed properly.
6. Fuel pump not functioning properly.
7. Insufficient lubricating oil pressure to keep the low pressure switch from operating.
8. Engine shut down cylinder or magnet valve not operating properly.
9. Insufficient oil supply in the governor.

ENGINE RUNS BUT THE SPEED WILL NOT INCREASE WITH THE THROTTLE SETTING

1. Engine control switch in the "idle" position.
2. Throttle magnet valve not operating properly.
3. Insufficient control air pressure.
4. Faulty governor, or governor actuator.
5. Control switch open.
6. Hot water switch closed.
7. Ground relay tripped, or fan relay tripped.

ENGINE OVERHEATS

1. Insufficient water supply.
2. Automatic shutter control not operating properly. Try fan and shutter switch in "on" position.
3. Engine overloaded.
4. Faulty fan motor circuit. Check fan contactors.
5. Cooling system circulating pump not functioning.

ENGINE STOPS

1. Fuel tank empty.
2. Low lubricating oil pressure, causing engine shutdown valve and cylinder to operate.
3. Emergency fuel shutoff valve has been tripped.
4. Engine overspeed stop tripped.
5. Control breaker, or emergency shutdown contactor, open.
6. Failure in fuel supply system.
7. Clogged fuel filter or strainer.
8. Shutdown valve not energized.

LOCOMOTIVE DOES NOT MOVE WHEN THROTTLE IS OPENED

1. Reverse lever in "off" position.
2. Control switches not set properly.
3. Power knockout switch fails to close.
4. Auxiliary generator field switch open.
5. Auxiliary generator breaker has opened.
6. Out-interlocks fail to close on generator starting or generator field contactors.

NO DYNAMIC BRAKING EFFORT

1. Fan relay cut-out switch off.
2. Traction motor cut-out switch open.
3. Shutter limit switches not closed.
4. Fans not running.
5. Poor contact of braking interlocks on cam switch.

BATTERY AMMETER SHOWS DISCHARGE (ENGINE RUNNING)

1. Auxiliary generator switch open.
2. Auxiliary generator field switch open.
3. Poor contacts on battery contactor or reverse current relay.

MISCELLANEOUS

1. Overspeed breaker (Speed Indicator) tripped.
2. Reverser (in Equipment Cabinet) does not throw.

NOTES

D I E S E L E N G I N E

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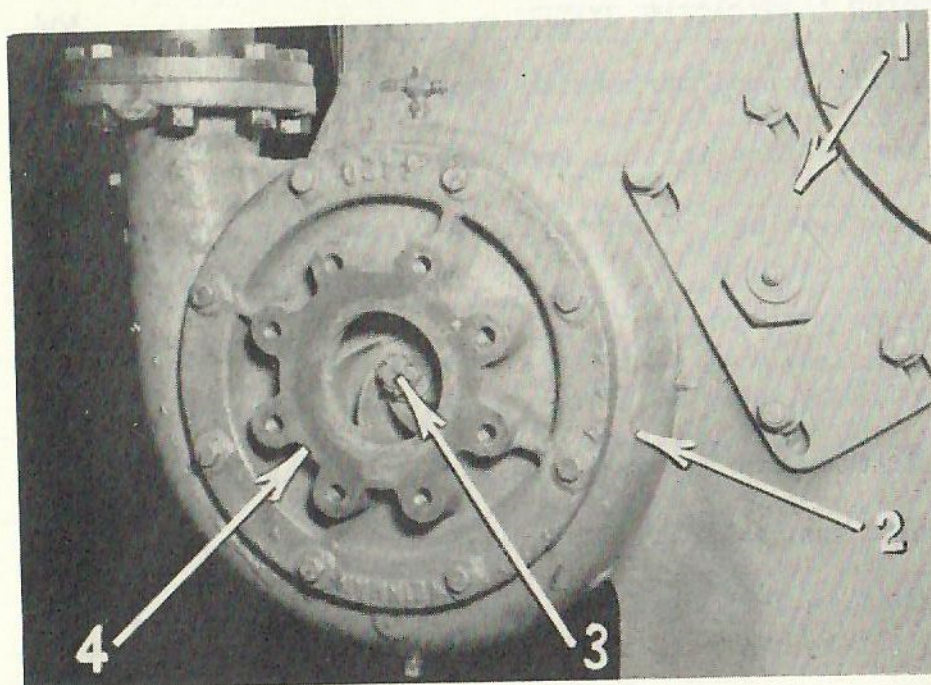
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A complete description of the diesel engine and its accessories is contained in a separate Diesel Engine Manual.

ENGINE ROOM

The space behind the electrical equipment cabinet may be termed the engine room. The engine, turbo-charger, air compressor, radiator, fans, cooling system controls, and accessories such as pumps and filters in the fuel oil system, and lubricating oil system, water pump and heat exchanger are mounted in this space.

Dynamic braking resistors, on locomotives so equipped, are located near the radiators. The electrically driven fans cool both the radiators and the braking resistors. The position of the shutter flaps is automatically controlled to direct the flow of air according to the needs of the radiators and resistors.



WATER PUMP AND IDLER BRACKET

Figure 1

1. Chain Idler Adjustment Bracket
2. Pump Casing
3. Impeller Nut (Left Hand Thread)
4. Pump Suction Head

ENGINE COOLING SYSTEM

RADIATORS, WATER PUMP AND HEAT EXCHANGER

Each engine is individually water cooled. Radiators for cooling the engine water, are built into the roof structure just back of the engine. Water is supplied to the engine header by an engine driven centrifugal pump and circulated through the engine cooling system. From there it passes into the engine discharge manifold and is piped to the radiators for cooling.

The cooled water circulates through a heat exchanger to cool the lubricating oil. It then returns to the water pump to resume its circuit through the system. (See Diagram, Fig. 2). The heat exchanger is located near the rear of the engine room.

FILLING OR DRAINING THE WATER SYSTEM

There is a connection on both sides of the locomotive for filling the cooling system. Water should normally be added to the system when engine is not in operation, preferably when engine is cold. If necessary to add water while engine is warm (above 120°F.), either heat the water or add it very slowly. Distilled or chemically treated water should be used in the engine cooling system. See Engine Manual or Maintenance Bulletins for detailed information.

In an emergency, the system may be filled through the filler cap on the roof over the radiator section. Regular use of this connection is not advised. Use of top filling connection when the expansion tank is empty has a tendency to produce air pockets in the system.

An expansion tank connected to the suction side of the pump allows for water expansion and accommodates a reserve supply to replace losses. A close check should be kept on the water level gauge at tank. If leaks are suspected, the crew should endeavor to locate them while the engine is warm and operating, and report to a maintainer. NOTE: The packing gland of the water pump is normally adjusted to leak about 3 or 4 drops per minute.

The main drain valve is also shown in the Cooling System Diagram. When draining as a precaution against freezing, be sure the heat exchanger and turbocharger

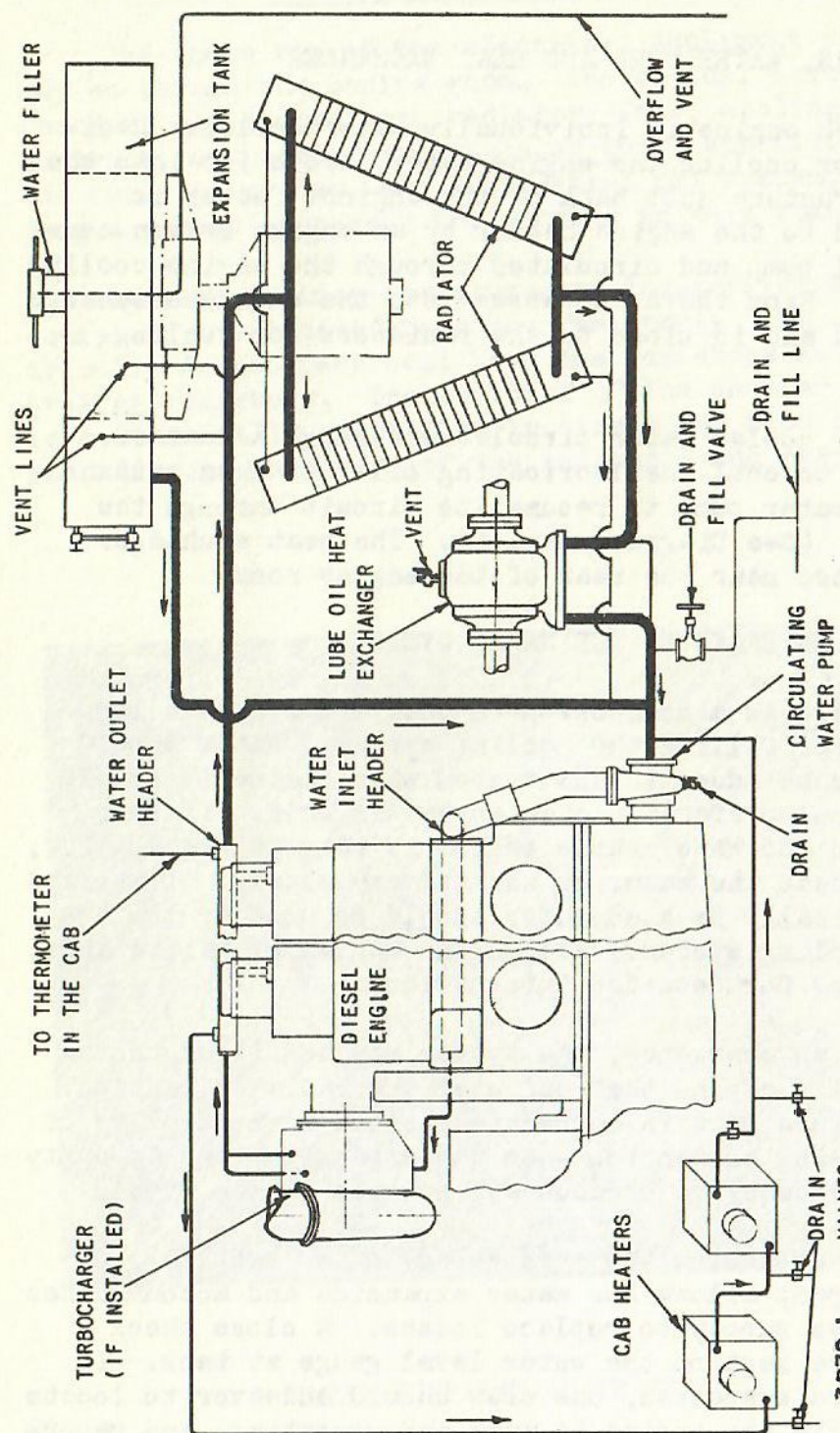


Diagram of Engine Cooling Water System
(Motor-Driven Radiator Fans)

Figure 2

are thoroughly drained also. There are two drain cocks on the turbocharger, one of which is for condensation.

TEMPERATURE CONTROL

Water temperature in the engine cooling system is normally regulated automatically by keeping the fan and shutter switch in the "auto" position. As water temperature rises and falls, the speed of the fans is regulated by an engine temperature controller. Temperature switches are opened and closed in a definite sequence by the controller which is adjusted to operate in a definite relationship to water temperatures. The temperature switches determine the position of fan motor contactors which determine the fan speed.

Water temperature should register between 145° F. and 165° F. If the water gets too hot, a water temperature switch will automatically idle the engine. If automatic temperature control does not function properly, fans may be operated at intermediate speed (directly from generator voltage) by placing the fan and shutter switch in the "on" position.

Shutters are set automatically by shutter valves which are described in the electrical section. During dynamic braking (when installed), large shutters take a position permitting air to pass over the braking resistors, small shutters permit sufficient air to pass through the radiators to cool the engine, and a different combination of fan contactors (independent of the automatic controls) closes the fan motor circuit. Limit switches are connected to the shutter rods to provide interlocking in the electrical control circuits.

ENGINE LUBRICATING SYSTEM

An independent lubricating system of the wet sump type as shown in the diagram, is used for each engine. Oil from the engine base is drawn through a suction strainer by a positive displacement gear pump, chain driven from the crankshaft. A check valve is situated between the engine base and the strainer. From the pump the oil passes through a full flow filter and a metal edge strainer into a heat exchanger for cooling. It is then delivered to the engine distribution system. The water connections of the heat exchanger are shown in Fig. 2.

Handles on the metal edge strainer should be turned a few revolutions every four hours. Should pressure on the system become excessive, a relief by-pass valve set at 125 pounds will spill the pump output into the engine base. If the pressure drop through the heat exchanger exceeds 25 pounds due to an accumulation of dirt, the heat exchanger will be by-passed by a relief valve.

FILLING THE LUBRICATING SYSTEM

Lubricating system is filled through filler cap on valve gear side of engine base at pump end. Oil level should be maintained between high and low mark on dip stick adjacent to oil filler cap. Oil level should be checked daily, but not until at least five minutes after engine has been stopped. Lock cocks on the piping below the filters drain the system.

LOW LUBRICATING OIL PRESSURE SHUTDOWN

A safety device is incorporated in the fuel system which will shut the engine down if lube oil pressure drops below approximately 15 pounds. This device, illustrated in Fig. 4, consists of switch "A", a solenoid operated shutdown valve "B" and a shutdown unit "C".

Switch "A" is operated by the pressure in the lube oil header. During normal operation it is held in the closed position permitting current to energize solenoid "D" which then keeps valves "E" open and "F" closed. When valve "E" is open, supply line "G" is in

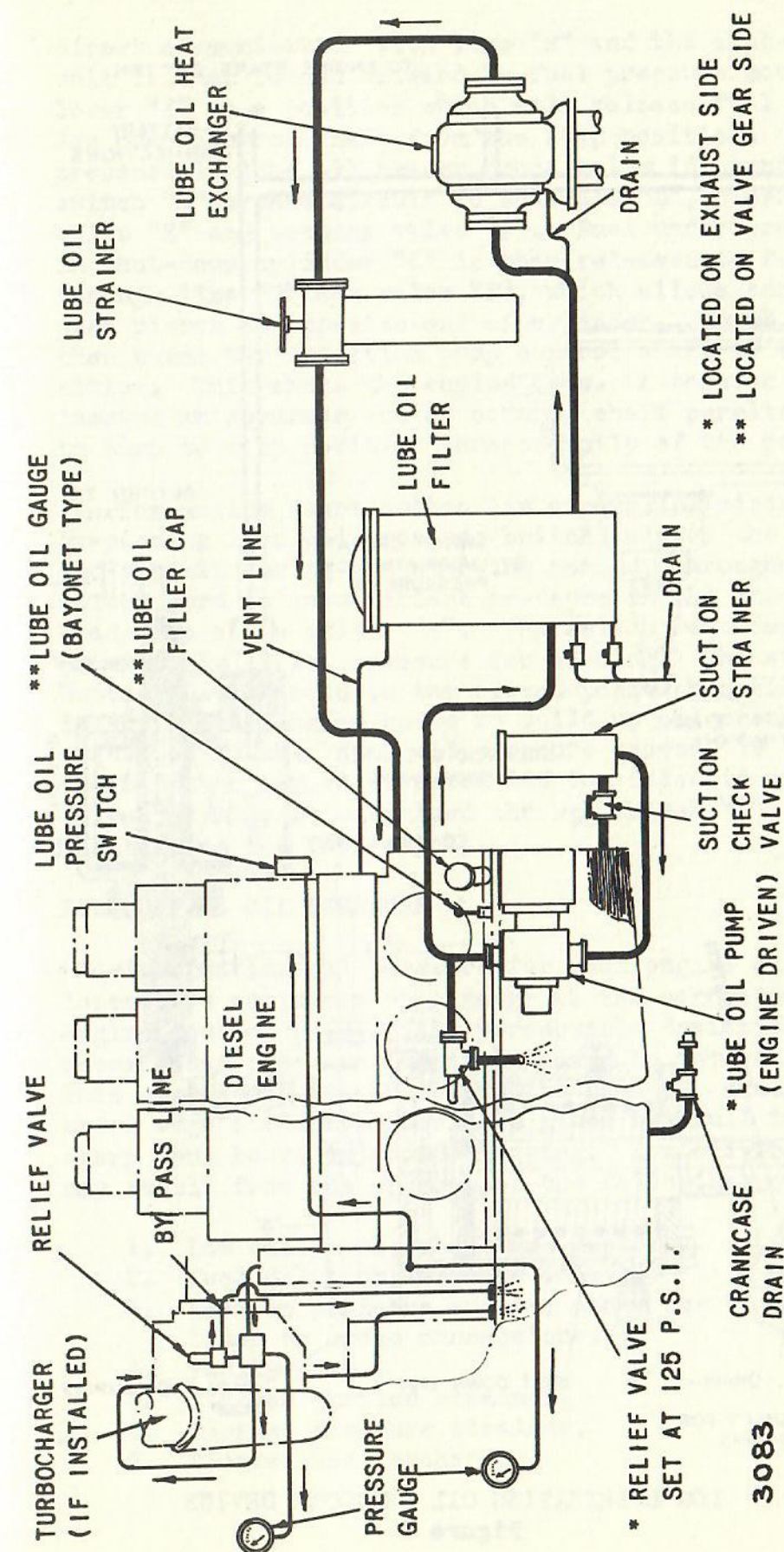
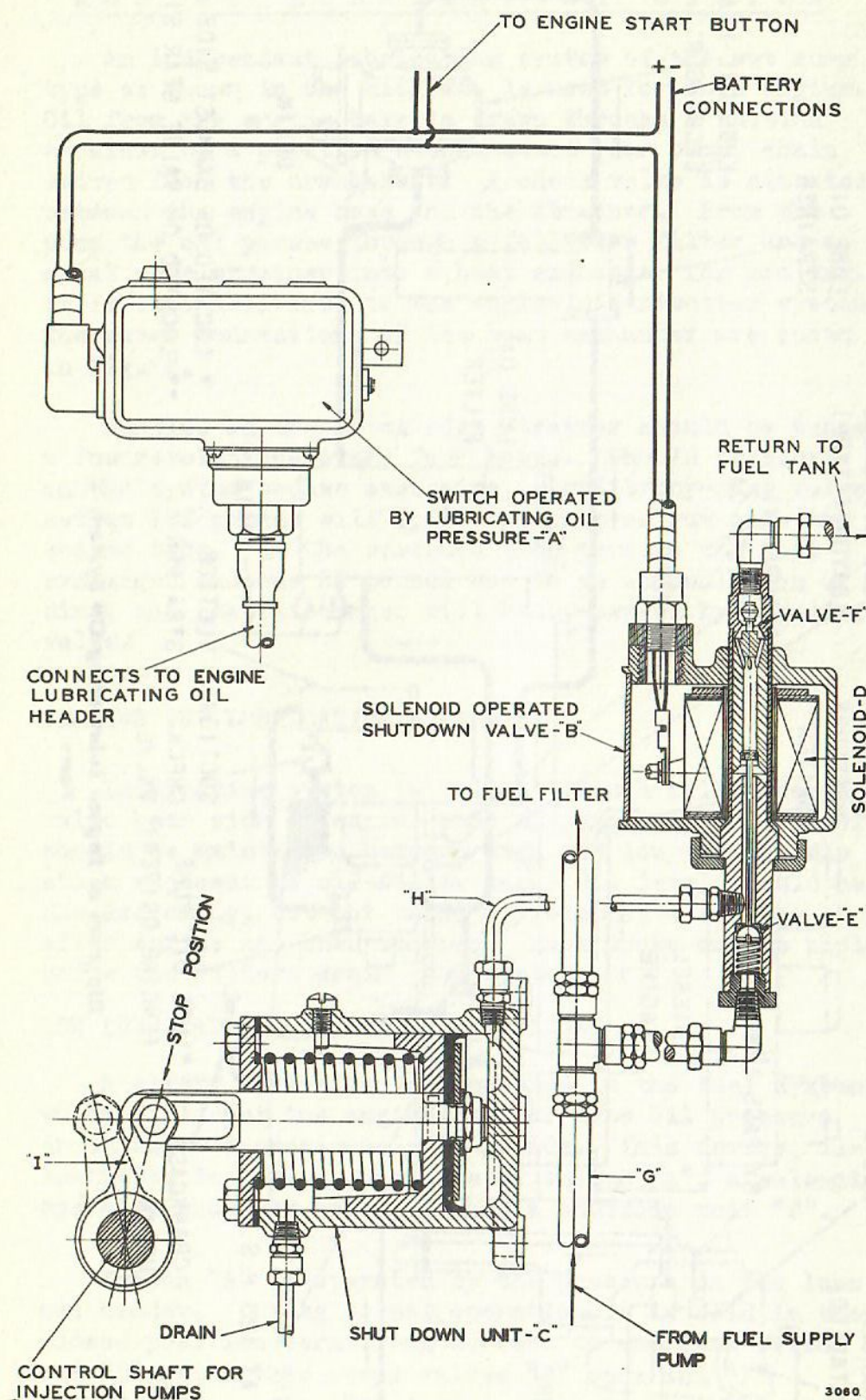


Diagram of Engine Lubricating Oil System
Figure 3



LOW LUBRICATING OIL SHUTDOWN DEVICE
Figure 4

direct communication with line "H" and the shut-down unit is then forced outward by fuel pressure moving lever "I" to a position which will release fuel injection pump control shaft from the stop position. When pressure in lube oil header drops below 15 pounds, switch "A" breaks circuit to solenoid "D", closing valve "E" and opening valve "F". Fuel under pressure in shut-down cylinder "C" is then released to fuel tank through line "H" and valve "F", which allows spring to push piston to opposite end of cylinder. Lever "I" then turns the injection pump control shaft to stop position. This shuts the engine down. A torsion spring located at governor end of control shaft permits shaft to turn to stop position independently of the governor.

The engine start button (in a parallel circuit, by-passing lube oil pressure switch) closes the solenoid circuit during the starting period, throughout which there is insufficient pressure in the lube oil header to close switch "A". The switch requires approximately 19 lb. pressure for closing. The start button must be held in the closed position until there is sufficient engine speed to build up oil pressure in excess of 19 lb. When oil pressure exceeds 19 lb., the start button may be released and the solenoid operated valve "B" will be energized through switch "A", thus maintaining the fuel supply.

LUBRICATING OIL PRESSURE

Lubricating oil pressure for each engine on the locomotive registers on a gauge at the corresponding engine control panel. Any perceptible deviation from recommended pressure (50 lb.) should be investigated. This corresponds to 65 lb. at the header. Handles on metal edge strainers should be given two full turns every four hours to avoid clogging. Low oil pressure may result from one or more of the following:

1. Low oil level; check and restore.
2. Fuel dilution; replace oil.
3. Leak in pressure system; check for broken lines or loose connections.
4. Faulty pump.
5. Clogged suction strainer.
6. Clogged pressure strainer.
7. Clogged heat exchanger.

ENGINE FUEL SYSTEM

Fuel is supplied to the engine by a motor-driven supply pump. The pump draws fuel from the tank through a metal edge suction strainer, and forces it through a cartridge-type filter to the fuel header supplying the fuel injection pumps. The fuel supply header is connected to a relief valve set to open at 25 lb. pressure. The excess oil supplied to the header, particularly during idling and light load periods, returns to the fuel tank through this relief valve. Another relief valve located at the supply pump protects the pump against excessive pressure.

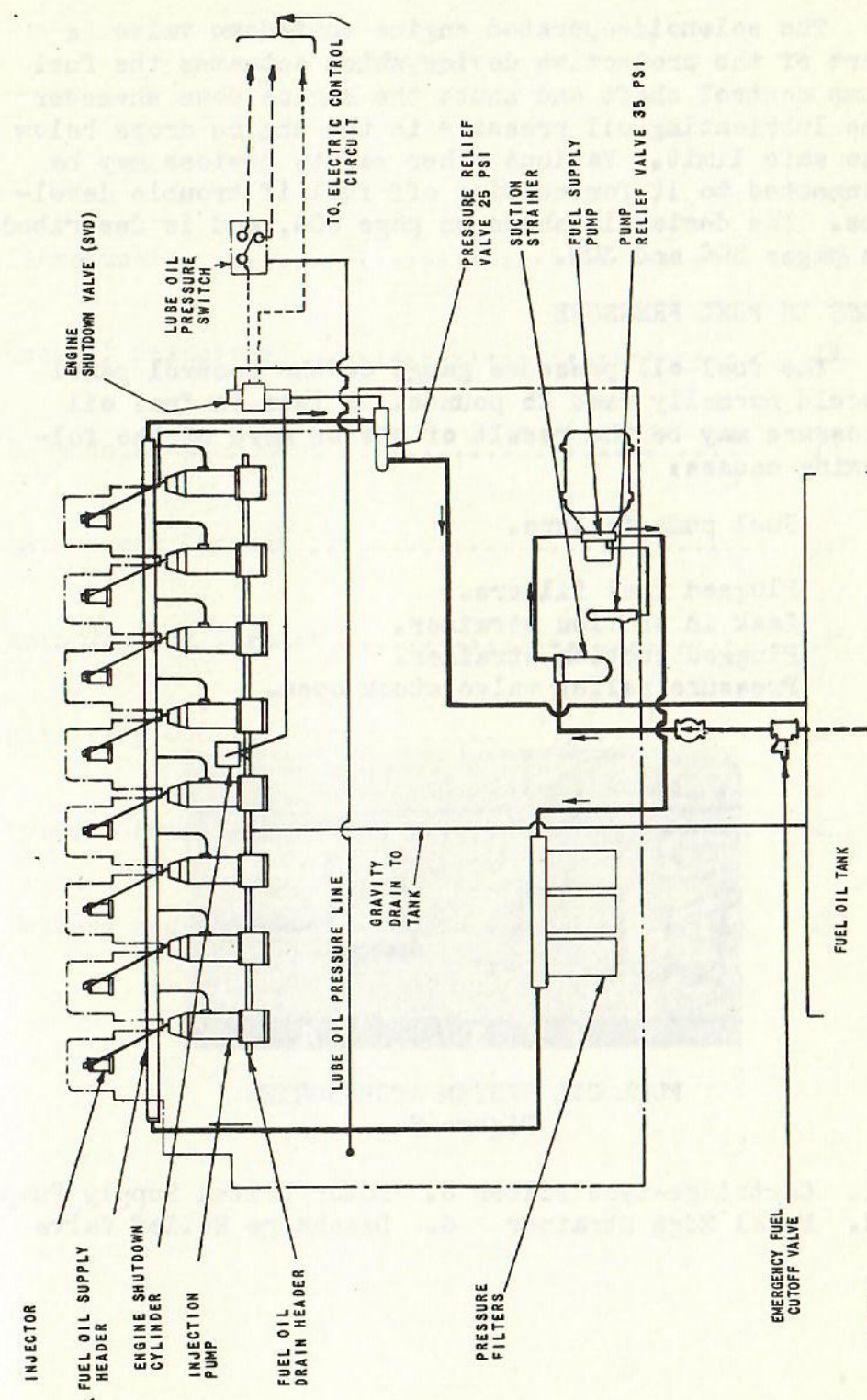
FILLING FUEL TANK

The fuel tank is suspended beneath the underframe between trucks. It can be filled from either side of the locomotive. A fuel gauge is installed in the side of the fuel tank. A manually operated emergency cut-off valve in the suction line is described in Section 2.

FILTERS AND STRAINERS

The filter on the pressure side of the supply pump is a cartridge type having replaceable elements which should be changed periodically. (A 3-unit type is shown in Figures 5 and 6, but many installations consist of only 2 units).

The metal edge type strainer on the suction side of the supply pump protects the pump. A drain plug in the bottom allows dirt to drain from the casing. Drain only when shut down so the pump does not draw air and lose its prime. The element should be removed periodically for inspection and cleaning.



ENGINE FUEL OIL SYSTEM DIAGRAM
Figure 5

3074 R2

SHUTDOWN VALVE

The solenoid-operated engine shut-down valve is part of the protective device which actuates the fuel pump control shaft and shuts the engine down whenever the lubricating oil pressure in the engine drops below the safe limit. Various other safety devices may be connected to it for cutting off fuel if trouble develops. The device is shown on page 308, and is described on pages 306 and 309.

LOSS IN FUEL PRESSURE

The fuel oil pressure gauge on the control panel should normally read 25 pounds. A loss in fuel oil pressure may be the result of one or more of the following causes:

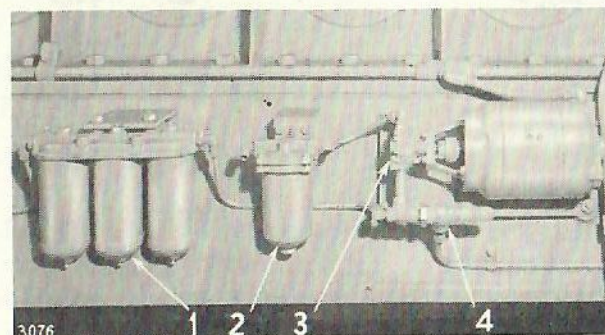
Fuel pump failure.

Plugged fuel filters.

Leak in suction strainer.

Plugged suction strainer.

Pressure relief valve stuck open.



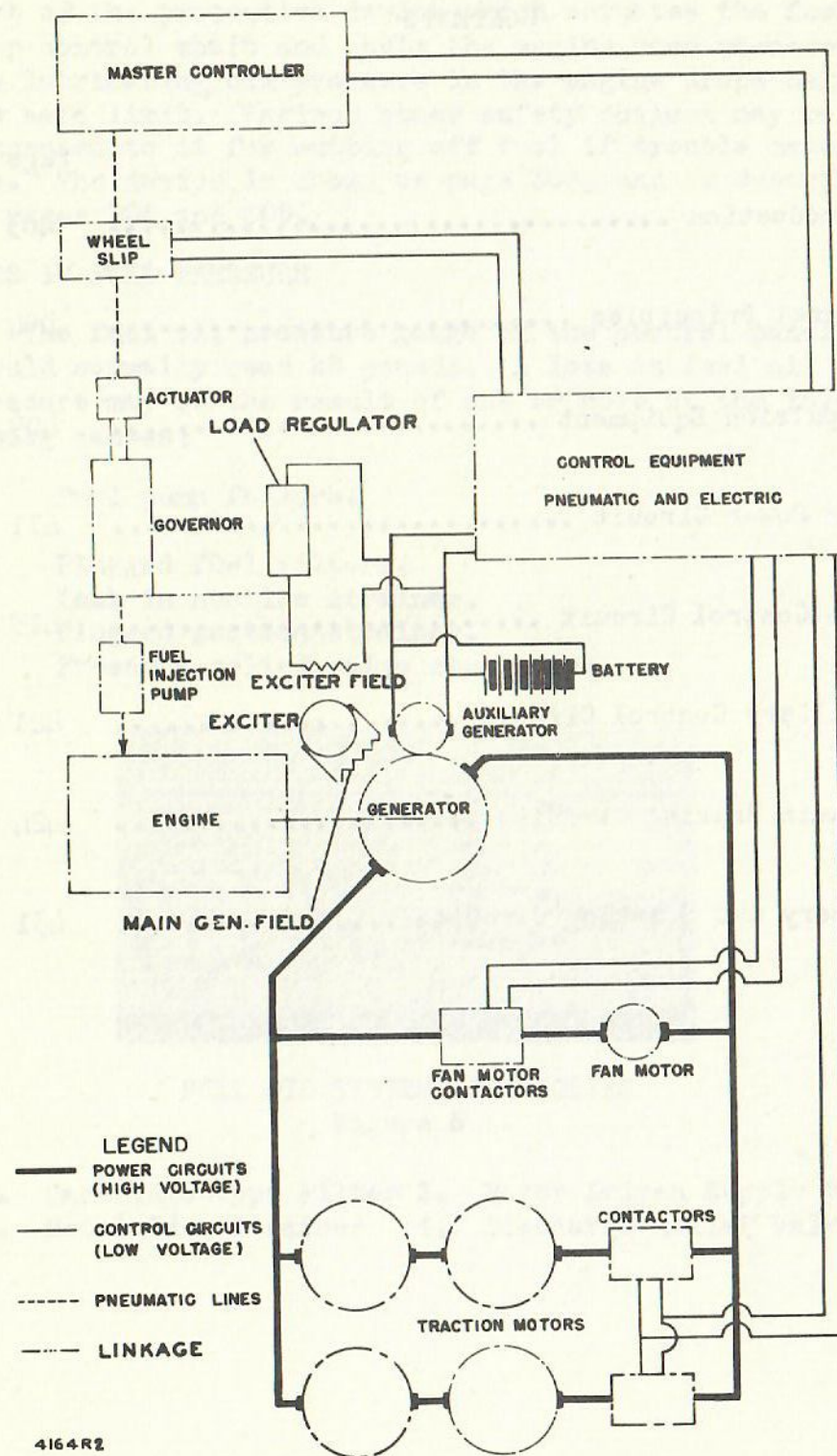
FUEL OIL SYSTEM ACCESSORIES
Figure 6

1. Cartridge-type Filter
2. Metal Edge Strainer
3. Motor Driven Supply Pump
4. Discharge Relief Valve

ELECTRICAL EQUIPMENT

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CONTROL SYSTEM DIAGRAM
Figure 1

ELECTRICAL EQUIPMENT

INTRODUCTION

This section describes the function and operation of the various pieces of electrical equipment and their relationships in the various circuits. The electrical equipment of the locomotive consists of the following main elements.

- a. Main Generator - driven by a Diesel engine.
- b. Traction Motors - geared to the driving axles.
- c. Power Control Equipment.
- d. Auxiliary Equipment and Controls.
- e. Lights, Heating, and Miscellaneous Equipment.

The Control System Diagram in Fig. 1 shows the basic relationship of the principal electrical equipment, together with a schematic layout of the related pneumatic control lines. The Master Controller in the upper portion functions (a) pneumatically through the governor and fuel injection pump to control the engine speed and power (via the dotted line), and (b) electrically through the control circuits to the traction motor contactors and auxiliary motor contactors. (See legend on Fig. 1 to identify power and control circuits.) The engine driven generator supplies the power circuits, while the auxiliary generator charges the battery and furnishes a regulated low voltage power supply to the control circuits. The battery is shown in normal operating connection. Special starting circuits from the battery are explained later. Many details of the circuits are purposely omitted to facilitate understanding.

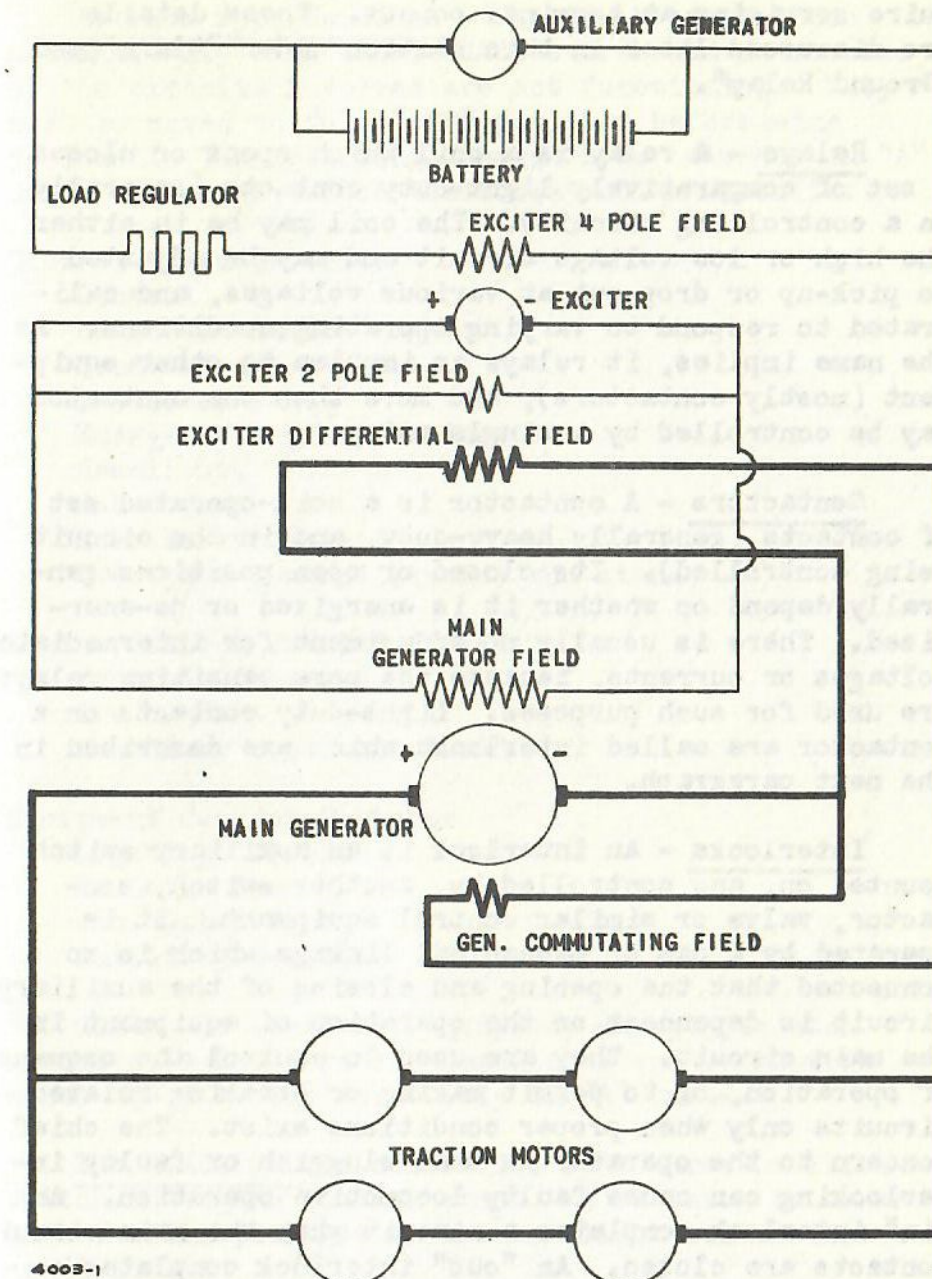
A power unit consists of one engine, one generator, four traction motors and certain auxiliary equipment, all of which are entirely independent of any other power unit, except that all are controlled by one master controller, and the alarm and emergency shut-down wires are connected to all units. "A" and "B" locomotive units are alike except for minor details in lighting, heating, sanding and power control.

GENERAL PRINCIPLES OF OPERATION

Each Diesel engine drives a generator which in turn powers the traction motors over various heavy duty high voltage circuits. A simplified schematic diagram of these connections is shown in Fig. 2. In starting, a high tractive effort and torque are necessary. The motor torque is proportional to the amperage, therefore a high current is required. Since there is no counter electro-motive force at stand still, and the motor's internal resistance is low, the current is high at low generator voltage and low generator speed. As the locomotive speed increases, the combined motor resistance and counter electro-motive force increases, the generator voltage must be increased by increasing its speed, if high current is to be maintained. The speed of the engine-generator is pneumatically controlled by the throttle lever and governor. The amperage drops rapidly after the initial acceleration. The voltage increases to a maximum of about 960 volts as the generator speeds up. The exciter fields are so arranged that, at any engine speed, the maximum power input to (or output from) the generator is nearly constant. Under such conditions, the product of tractive effort x speed is constant for all speeds, and the product of generator voltage x amperes is constant for all amperages.

A low voltage circuit, 75 volts, is provided for as much of the auxiliary equipment and control apparatus as can possibly be removed from the high voltage circuits. This circuit is supplied by an auxiliary generator which also charges a battery for supplying the circuit when the power unit is not running.

Controls - Controls fall into two main classes, manual and automatic. In general, the manual controls are those required in starting a power unit, operating the locomotive, and emergency operation, isolation, or shutdown of portions of the locomotive while continuing operation with the remaining equipment. Automatic controls are protective or interlocking in nature or relieve the crew of incidental operating details necessary for efficient operating such as (a) field shunting of the traction motors and fan motors, or (b) load regulation of the exciter field circuit for smooth acceleration. Some of the protective devices



SIMPLIFIED SCHEMATIC WIRING DIAGRAM
Figure 2

function regularly in normal operation, while others function only when abnormal conditions arise. In many instances the proper attention to gauge readings, such as those for lube oil pressure and cooling water temperature, will reveal the trouble in advance, but should the crew fail to detect such conditions, the protective devices will function. An alarm system warns the crew of abnormal conditions. Some abnormal conditions may be rectified enroute, while others re-

quire servicing at terminal points. These details are discussed later in this section under "Alarm" and "Ground Relay".

Relays - A relay is a coil which opens or closes a set of comparatively light-duty contacts (generally in a controlling circuit). The coil may be in either the high or low voltage circuit and may be adjusted to pick-up or drop-out at various voltages, and calibrated to respond to varying operating conditions. As the name implies, it relays an impulse to other equipment (mostly contactors), and more than one contactor may be controlled by a single relay.

Contactors - A contactor is a coil-operated set of contacts (generally heavy-duty, and in the circuit being controlled). Its closed or open positions generally depend on whether it is energized or de-energized. There is usually no adjustment for intermediate voltages or currents, because the more sensitive relays are used for such purposes. Light-duty contacts on a contactor are called interlocks which are described in the next paragraph.

Interlocks - An interlock is an auxiliary switch mounted on, and controlled by, another switch, contactor, valve or similar control equipment. It is operated by a cam or mechanical linkage which is so connected that the opening and closing of the auxiliary circuit is dependent on the operation of equipment in the main circuit. They are used to control the sequence of operation, or to permit making or breaking related circuits only when proper conditions exist. The chief concern to the operator is that sluggish or faulty interlocking can cause faulty locomotive operation. An "in" interlock completes a circuit when the main circuit contacts are closed. An "out" interlock completes a circuit when the main circuits contacts are open.

Electro-Pneumatic Valves - An electro-pneumatic valve consists of an electro-magnetic coil which actuates valves in the air lines. The coils are part of the electrical circuits and are shown in the wiring diagrams, but reference must be made to the Air Piping Diagram in Section 6, for the pneumatic portion of such equipment as, for example, the Compressor Valve, Throttle Valve, Sander Valves, Overspeed Valve, Power Switches and Reverser.

Breaker Type Switches - Circuit breakers open automatically when overloaded, and should be checked if the circuits involved are not functioning. They must be moved to full "off" position before being reclosed. The following breaker type switches in "A" units are connected in their respective circuits.

Control Stand Switches

- Control
- Gauge and Number Lights
- Front Marker Lights
- Defroster Fans
- Emergency Engine Shutdown
- Headlight
- Cab Signal
- Rear Marker Lights
- Overspeed Control (inside the stand)

Engine Control Panel Switches

- Control (35-amp.)
- Ground Relay Cut-out
- Auxiliary Generator Field

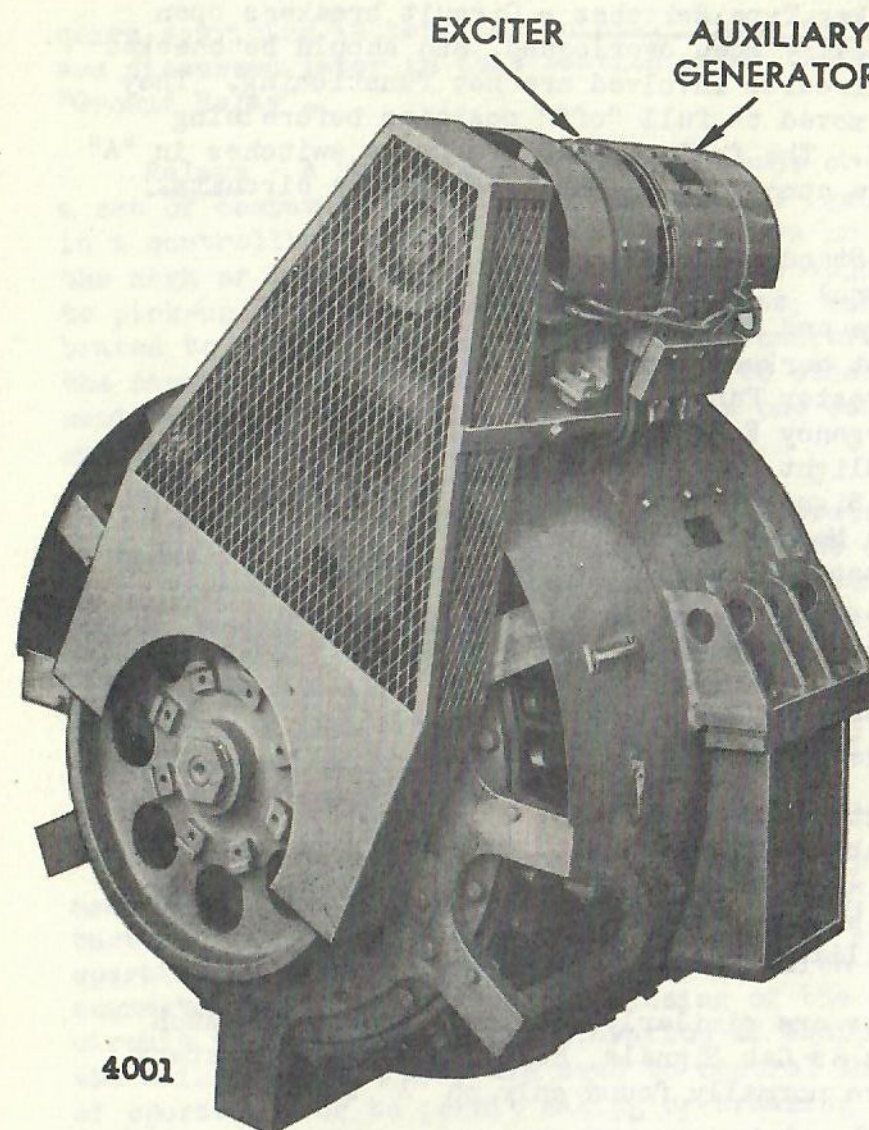
Equipment Cabinet Switches

- Lighting Circuits
- Radiator Fans
- Cab Heater Fans
- Auxiliary Generator Switch

"B" units are similarly equipped, except for such circuits as Cab Signals, Headlights and Defrosters which are normally found only on "A" units.

The headlight is controlled by a three-position switch on engine control stand. A resistor in series with the dim position of the headlight switch dims the headlight.

Standby Lighting, if provided, connects the engine room, cabinet and cab lights through a transfer switch and transformer to outside 115-volt, 60 cycle, a-c power. The switch and transformer are at rear of "A" units, and "B" units, and an outside connecting receptacle is provided.



MAIN GENERATOR AND TRACTION MOTOR
Figure 3

PROPULSION EQUIPMENT

MAIN GENERATOR

The main generator, shown in the top portion of Fig. 3 is a 12-pole d.c. self-ventilated single bearing generator directly connected to the Diesel engine by a coupling. It furnishes power over a wide range of speeds up to 625 r.p.m. and rotates in a counter-clockwise direction when viewed from the commutator end. It supplies power to the traction motors, and radiator fan motors.

AUXILIARY GENERATOR AND EXCITER

The auxiliary generator and exciter unit on the main generator frame (Fig. 3) is belt driven by the main generator.

The auxiliary generator is about 10 KW capacity. It charges the battery, supplies power to the fuel pump motors and heater fans and energizes the control equipment. It is regulated for constant voltage by a vibrating type voltage regulator. The auxiliary generator circuit is protected by a breaker switch in the equipment cabinet, which opens automatically if overloaded.

The exciter supplies the main generator fields, and is specially wound to maintain power output as nearly constant as possible. To avoid overloading the engine, the strength of the main generator field must be varied so that the generator voltage is decreased as the current demand is increased. To do this the exciter has three separate field windings, as follows:

- (a) A 2-pole shunt field energized by exciter current.
- (b) A 4-pole field energized by the auxiliary generator and fed through a load regulator.
- (c) A reversed (differential) field energized by main generator current.

The connections for these fields are shown in the Schematic Wiring Diagram in Fig. 2. When current from the main generator to the traction motors is high, the reversed field opposes the other exciter fields which

weakens the main generator fields and reduces the voltage and current supplied to the traction motors. The exciter is designed so that its inherent differential characteristics automatically decrease the field strength, and hence the voltage, of the generator as the current demand increases.

TRACTION MOTORS

The traction motor, shown in the lower portion of Fig. 3 is a direct-current, series-wound 6-pole motor mounted on, and geared directly to, each driving axle. Four motors are connected to each main generator as shown on the Simplified Schematic Wiring Diagram in Fig. 2. The motor connection remains the same for all running conditions. The field connections are reversed to reverse the direction of rotation of the motors. They are force-ventilated by mechanically driven blowers through ducts in the locomotive underframe feeding into openings in the top of the motors.

MAIN POWER CIRCUITS

PNEUMATIC POWER SWITCHES

Traction motor power switches, P1 and P2, are electro-pneumatically operated and connect the traction motors to the generators. When their coils are energized by the closing of the FR contactor, they close and power is supplied to the traction motors. The coils are fed through a manually operated rotary cut-out switch which can be set to open either, or both, of the P-switches, thus cutting the traction motors out of service. These switches are located in the equipment cabinet.

CAM SWITCH

On locomotives equipped for dynamic braking, traction motor connection during braking differs from that during motoring. A cam switch controls the changeover. It has a motoring position and braking position, pneumatically operated by CSM and CSB valves. Contacts CSM1 and CSM2 are closed during motoring, and CSB1, CSB2, CSB3, CSB4 and CSB5 are open during motoring. Several fan control and power control circuits are fed through interlocks on this switch. The changeover is described in sequence under Dynamic Braking.

REVERSER

The reversers control the direction of rotation of the traction motors by reversing the direction of current through the field windings, thereby reversing the direction of locomotive travel. A pneumatically operated cylinder rotates the drum to change connections. The cylinder is controlled by magnet valves which are connected to a small reverser drum in the master controller. The reverser is located in the equipment cabinet. If it does not rotate in response to the controller setting, the plunger button on the magnet valve may be pressed in, or a lever may be applied to the handle at the bottom, to move it manually.

TRACTION MOTOR FIELD SHUNTS

The traction motor fields are shunted to provide a by-pass for a portion of the field current after the locomotive speed has reached a point where full Diesel engine power output under normal field strength is not

absorbed. The field is automatically weakened in four steps, thus increasing speed and making use of full power output over a wider locomotive speed range than would be otherwise possible. The field shunting controller is connected across main generator voltage so that its rotating element energizes a successively greater number of field shunting contactors as locomotive speed increases. The field shunt resistors are located on the equipment cabinet.

RADIATOR FAN MOTORS AND CIRCUIT BREAKER

Two fan motors are connected in series across the main generator. They are series wound motors located near the roof of the radiator compartment. They are protected against overload by a 120-amp. breaker in the equipment cabinet.

A resistor is provided to shunt the fan motor fields. This maintains high fan speed at low generator voltages if the water temperature is high enough to close the temperature control switches which control the field shunting circuit. The field shunt resistor is located on the equipment cabinet.

FAN MOTOR CONTACTORS

Fan contactors F1, F2 and F3 are controlled by temperature switches which are actuated by an engine temperature thermostat. Fans operate at 3 speeds: Low, Medium and High. The circuit for each speed is as follows:

Low Speed - From a point between the traction motors through contactor F1, contactor F2 being open. This puts only partial generator voltage across the fan motors.

Medium - F2 closes after F1 opens, putting full generator voltage across the two fan motors.

High - F3 closes, F2 remaining closed, cause's shunting of fan motor fields while retaining full generator voltage on the motors.

WHEEL SLIP RELAYS

The wheel slip relays and resistors are connected around each set of traction motors. They operate a throttle valve which automatically reduces power when the wheels slip. If one pair of wheels is locked due to mechanical or electrical failure, the wheel slip buzzer will sound continuously as soon as sufficient speed has been attained to establish a voltage differential from the normally operating traction motor.

The coil of the relay is connected between the traction motors and the wheel slip resistor so that, under normally balanced conditions, no current flows through the coil. When a pair of wheels slips, the unbalanced voltage condition causes current to flow through the coil to close the relay. The contacts of the relay give a buzzer warning to the engineer and energize the throttle valve which reduces the speed of the engine. The buzzer is train-lined to all units, but engine speed is reduced only on the slipping unit.

GROUND RELAY

If any portion of the high voltage circuit becomes grounded, current flows through the ground relay GR which idles the engine, sounds the alarm bell and lights a light on the equipment cabinet, and opens the power control contactor FR. Details of the alarm circuit are discussed later under Auxiliary Control Circuits.

FAN DIFFERENTIAL RELAY, ALARM AND CUT-OUT SWITCH

The fan differential relay protects the cooling system and braking resistors against failure of the fan motors. A defective fan-motor circuit causes the relay to pick up, thus opening the power and braking circuits, and actuating the alarm bells and lights. Opening the cut-out switch permits emergency pulling (but not braking) if cooling system is not hot enough to idle engine. It is almost never opened.

LOAD AMMETER

An ammeter is located on the engineer's instrument panel in the cab and shows the current through traction motors No. 1 and No. 2. (An equal amperage normally

flows through motors No. 3 and No. 4.) See Load Limits in Operating Section of this book for permissible loads. The shunt for this ammeter is located in the equipment cabinet.

MAIN CONTROL CIRCUIT

CONTROL CONTACTOR AND MASTER CONTROLLER VALVE

The control switch at the engineer's position must be closed to establish power control by the master controller at that location. Control contactor CR and Controller Valve MCV in the equipment cabinet are thus energized. The control contactor must be closed to complete the electrical circuits through the controller and the valve must be energized to admit air to the pneumatic control lines from the throttle.

When control is established through any controller, all other controllers in multiple are interlocked out of action. This is accomplished by contactor CR1 which is energized through the B+ train-line wire on all units except the controlling unit. An out-interlock on this contactor breaks the circuit to all non-controlling CR contactors and MCV valves.

POWER KNOCKOUT SWITCH AND CONTACTOR

The master controller is fed through Power Knockout Contactor PK. The contactor's coil is fed through a pneumatically operated Power Knockout Switch which opens when there is a deadman or overspeed brake application or when an emergency brake application is made. (In some installations this may be limited to application made in the cab, when so specified.) When the Knockout Switch opens, contactor PK is de-energized (opened), the control circuit becomes inoperative, the power is shut off and the engine is reduced to idling speed. When the brakes are restored to normal and the throttle is returned to "off", the Power Knockout Switch closes automatically and energizes PK. It is then kept energized (closed) through PK-in interlock, regardless of the setting of the controller, until either the control switch is opened, or an emergency brake application occurs. This switch and contactor are on "A" units only. The switch is located in the nose and the contactor is in the equipment cabinet.

MASTER CONTROLLER

A Master Controller at each operating position regulates the speed and determines the direction of travel through a throttle lever and reverser lever respectively.

The throttle lever controls the application of power to the traction motors by regulating (pneumatically) the fuel supply and hence the output of the diesel engines.

It has five notches throughout its angular travel. The first notch is "off" position in which the motors are disconnected. The second notch connects the motors across the generator with the latter delivering very low voltage for soft starting. Added movement of the throttle lever gradually builds up the generator voltage to its full value. At the high speed end of the throttle travel, three notches are provided for running positions.

The throttle lever actuates by means of a cam, a pressure regulating unit which is located in the lower left hand portion of the controller. Movement of the throttle lever increases or decreases the air pressure in the throttle pipe line in direct response to the magnitude of this movement. This varying air pressure operates an actuator which regulates the speed control shaft of the engine governor.

The reverse lever controls the direction of motion of the locomotive by reversing the traction motor fields. It rotates the reverser drum in the master controller which closes contacts to energize reverser valves FOR and REV, according to the setting of the lever. The action of these valves is described in the next main paragraph. The connections are shown in the right hand portion of the master controller. The lever can be placed in five positions as follows: 1 Off, 2 Forward, 3 Reverse, and 4 and 5 Dynamic Braking.

In the "off" position the engines can be speeded up by means of the throttle lever to maximum speed without moving the locomotive. This permits rapid pumping of air by the air compressor if necessary.

In the "reverse" or "forward" position, a movement of the throttle handle results in a corresponding locomotive movement.

In the Dynamic Braking position the dynamic braking controls are energized through wire D, the cam switch moves to braking position to change the traction motor circuits to braking connection, and power switch P1 is open, but P2 which opened while changing over, closes.

The reverse lever is mechanically interlocked with the throttle lever. This prevents moving the reverse lever if the throttle lever is not in the "off" position. In addition, a protective latching device prevents movement of the lever to the dynamic braking position until it is deliberately released.

"B" Unit Controls - The controls on the "B" unit are intended for hostler's yard movements only, as described in Section 2. The throttle is entirely pneumatic. The reverse lever is mounted separately, and can be placed in only 3 positions, Off, Forward and Reverse. There are no dynamic braking controls in the "B" unit, and only 3 electrical contacts in the controller reverse drum are involved, F, 4, and R, instead of 7 contacts as on "A" units. The reverse lever on "B" units is electrically interlocked to prevent its movement if the throttle is not in the "off" position. This is accomplished by a locking coil which is energized through a throttle switch that closes automatically when the throttle is advanced. The throttle switch is located at the hostler's controls.

REVERSE MAGNET VALVES

The reverser magnet valves, which are connected to the Master Controller as outlined above, are built into the Reverser to control its operating cylinder. On the leading unit, when the reverse lever is in Forward position, valve FOR is energized; when in Reverse position, valve REV is energized. The jumper between units automatically connects the trailing units so that the proper reverser valves are energized. (On any trailing unit traveling backwards, the opposite valves are energized.) The reversers are thereby moved so that traction motor fields are connected for rotation corresponding to the setting of the reverse lever.

ENGINE CONTROL SWITCH

A manually operated 3-position rotary engine control switch, mounted on the engine control panel, governs the operation of the main control, auxiliary control and starting circuits. In the "off" position (see nameplate on control panel), the engine is shut down. In the "on" position, the switch feeds contactors which must be energized to maintain the control, excitation, and fuel supply circuits (FR, EF and SDV respectively). It is also the only position in which

dynamic braking will function. In the "idle" position, the fuel supply is maintained, the engine is restricted to idling speed by energizing the throttle valve, and the control circuits are de-energized thus opening the power circuits. The switch is set in the "idle" position if it is necessary to isolate an entire power unit, while continuing to pump air, circulate warm water through the radiators, keep the fans running or keep the battery charged.

POWER CONTROL CONTACTOR

Contactors FR is energized when the throttle is advanced (providing the reverse lever is set for forward or reverse travel). It closes when energized which, in turn, energizes (closes) power switches P1 and P2 to complete the main power circuit. Therefore, the traction motors are connected to the generator only when they are receiving power. This contactor is in the equipment cabinet.

GENERATOR AND EXCITER FIELD CONTACTORS

Electro-magnetic contactors GF and EF in the equipment cabinet must be closed to complete field circuits for the main generator. When the throttle or engine control switch is in idling position, the circuit through FR-out, P1-out, etc., energizes (closes) these contactors in order to maintain power supply to the fan motors. When the engine is working, power switches P1 and P2 are closed, and the field contactors are energized through the in-interlocks of the power switches, instead of the out-interlocks which are now open. During braking, GF is de-energized but the exciter 4-pole field is maintained at a different strength by the re-closing of contactor EF.

GROUND RELAY

The ground relay lights an indicator lamp, opens the power control contactor FR, and field contactors EF and GF, idles the engine through throttle valve TV on the grounded unit and rings the alarm bell on all units. A ground relay reset button and out-out switch are on the engine control panel.

The ground relay may be energized by some transient condition in which case it may be reset by pushing the Ground Relay Reset Button and normal operation resumed.

A single ground is from either the positive or negative line to the grounded frame, and the electrical circuits are not seriously affected until a double grounded condition produces a short circuit. If there is no short circuit, the ground relay cut-out switch may be manually opened to open the relay and de-energize the throttle valve and permit the limited use of the power unit, if necessary, until a railroad terminal is reached. The power unit should be idled or shutdown if there are major faults which cannot be rectified.

FAN DIFFERENTIAL RELAY, LIGHT AND RESET BUTTON

The fan differential relay opens contactors FR, EF and GF when the fan-motor circuit is defective, thus opening the power and braking circuits. The alarm rings and the "fan warning" light on the engine control panel gives an indication that the relay has picked up. The relay has a holding coil which keeps it closed after it has once picked up. If the defect was of a temporary nature, or has been rectified, the fan relay reset button on the engine control panel must be pressed momentarily to restore the fan relay to normal.

TRACTION MOTOR CUT-OUT SWITCH

A traction motor cut-out switch, connected in series with the coils of the power switches, may be manually set to de-energize P1 or P2, which opens the corresponding power circuit. It is a rotary switch in the equipment cabinet, and the circuits cut out in its various positions are designated on its nameplate. When a P-switch opens, the exciter field circuit is also changed, thereby automatically changing the generator output in proportion to the number of traction motors in service. The traction motor cut-out switch is also connected in the dynamic braking circuit to render dynamic brakes inoperative if either P-switch is open. The switch setting should not be changed under heavy load.

EMERGENCY ENGINE SHUTDOWN CONTACTOR

Closing the manually operated emergency engine shutdown switch on any control stand energizes (opens) emergency shutdown contactor ES on all multiple connected "A" and "B" units, opening the circuits to the fuel pump motor, and fan and shutter switch. Contactor

ES is located in the equipment cabinet.

TRACTION MOTOR FIELD SHUNTING CONTROLLER

As the locomotive speed increases, four steps of field shunting occur automatically. The control circuits to the field shunting contactors are opened or closed by the cam action of a rotating element in the field shunting controller. The generator voltage, (which has a definite relationship to locomotive speed), determines the position of the rotating element. As it turns, M1 and M2 close first, then M3 and M4, then M5 and M6 and finally M7 and M8. The sequence occurs automatically in the reverse direction as locomotive speed decreases.

MULTIPLE UNIT OPERATION

Locomotives for train service are normally designed to operate in multiple with each other. This means that preliminary step E-1, page 209, provides control circuits to all connected units, and all but one of the controllers is interlocked out of action. These operating instructions cover the requirements to be met for multiple connection, but it is essential to remember that when uncoupled or disconnected control must be established on any disconnected unit, even though the design permits the diesel engine to continue running. While this is apparent if any attempt is made to run the locomotive, crews should remember a more essential factor, namely that an air compressor of a disconnected unit will not continue to pump air until its control switch is closed. Air brakes must not be relied upon to hold the locomotive until this requirement is met.

AUXILIARY CONTROL CIRCUIT

The auxiliary control equipment operates on 75 volt power supplied by the auxiliary generator. The three principal circuits are:

1. The cooling system controls fed through the fan and shutter switch.
2. Controls for idling the engine, and corresponding alarms when idling occurs automatically by the ground or wheel slip relays.
3. Miscellaneous sanding and compressor controls.

FAN AND SHUTTER CONTROL SWITCH

The fan and shutter switch is a small double-pole, double-throw, manually operated switch located on the engine control panel. It has three positions, as follows:

- Off - Fans will not operate. Shutter valve de-energized. Shutters close off the radiator.
- Automatic - Fan speed and shutter position are automatically regulated through temperature control switches.
- On - Fans operate at constant speed if automatic temperature switches fail.

TEMPERATURE CONTROL SWITCHES

The temperature switches are actuated by an engine temperature thermostat. When the fan and shutter switch is in the automatic position, their operation is in a fixed relationship to water temperature, so that the fan contactors change the speed of the fan motors as described on Page 412. These switches are not in the circuit when the fan and shutter switch is in the "on" position.

SHUTTER VALVES

Electrically operated shutter valves regulate the position of the shutters by pneumatic action. The shutter valves for each unit are located near the temperature control switches which are just described.

The large flap is controlled by SV2 which takes a position that permits cooling of the radiators during motoring, and cooling of the dissipating resistors during dynamic braking. The small flap is controlled by SV1. It permits adequate flow of air through the radiators when the large flap is set for braking.

TIME DELAY RELAYS

A time delay relay in each fan control circuit prevents F2 from closing before the circuit through F1 is completely interrupted. Refer to Fan Motor Contactors, Page 412, for description of their closing sequence.

THROTTLE VALVE

The throttle unloading valve TV reduces the pneumatic pressure on the governor, resulting in a decreased fuel supply. If actuated by the wheel slip relay, pressure (and fuel) automatically returns to the original value when the wheels stop slipping. Therefore, if the wheels start slipping repeatedly, the engineer should reduce the throttle setting. The throttle valve is mounted in the electrical equipment cabinet. It is actuated when the water temperature switch closes, the wheel slip relay or ground relay picks up, when the isolating switch is off, or when the Dynamic Braking Contactor BR2 is closed. It is not train-lined and fuel is reduced only on the individual unit where the foregoing conditions exist.

WATER TEMPERATURE SWITCH

Each unit has a water temperature switch mounted on the engine, which automatically closes at high water temperature to idle the engine. The alarm rings when this switch has closed.

ALARM

An alarm system rings a bell and lights a light on all units in multiple when any engine water switch closes, an engine shuts down, or fan differential or ground relays pick up. The ground indication is received through relay GR, and the shutdown indication through relay SG. SG and SDV are in parallel with each other and energized at the same time. Therefore

SG is open whenever SDV is energized to maintain fuel supply. When this circuit is de-energized and the fuel shut off, SG closes to sound the alarm bell. The ground relay has an indicating light, a reset button and a cut-out switch as described in a previous paragraph. An attendant call circuit is also connected to the alarm bell.

SANDER

Sander valve FSV in the equipment cabinet is energized through an interlock which permits sanding in the forward direction of each truck of "A" units, and the leading truck of the "B" units. (Some "A" units when designed for A-B-A operations do not sand when operating as a trailing unit.) The sanding interlock is fed through a pneumatically operated sander switch in the nose of "A" units which is closed by the sanding bail, or valve, in the engineer's cab. It also closes automatically during an emergency brake application. There is no sander switch on "B" units, but interlocked sanding valves FSV and RSV (forward and reverse) are fed through a train-line wire from the "A" units.

COMPRESSOR GOVERNOR SWITCH AND VALVE

A pneumatically operated compressor governor switch closes at low pressure on the main air reservoir and opens when the pressure builds up sufficiently. When closed, valve CV is energized, which permits the compressor intake valve to seat so the compressor pumps air. It is connected to wires B+ and C in the train-line circuit for multiple unit operation. The valve and compressor governor switch are located in the nose.

OVERSPEED VALVE

The overspeed valve, when installed, functions in conjunction with the locomotive overspeed control. It is usually mounted in the nose of "A" units. Its electrical coil is fed through a breaker type switch which must be closed in order to operate the locomotive. This switch is usually mounted inside the control stand.

D Y N A M I C B R A K I N G

In addition to the standard air braking equipment, the locomotive is equipped with dynamic braking in which the energy involved in retarding the train is dissipated in dynamic braking resistors instead of in the brake shoes. To accomplish this, the motors act as generators driven by the locomotive axles. They are connected to the resistor during braking only. The resistors, mounted in the roof of the locomotive, are fan cooled, and the fan motors are connected in parallel with the resistors to absorb a portion of the power. The traction motor fields are disconnected from the armature during dynamic braking and receive their excitation from the main generator in order to secure variable braking effort. Advancing the throttle during dynamic braking increases the field of the generator by pneumatic action on the Load Regulator in the generator field circuit. The engine and generator also speed up as the throttle is advanced. Both actions increase the fields of the traction motors, which increase the braking effort.

The connections for dynamic braking are made automatically when the reverse lever at the master controller is placed in the dynamic braking position, provided the Engine Control Switch is in the "on" position. Wire D in the control circuit becomes energized when the controls are set for dynamic braking. This energizes valve CSB and throws the cam switch to braking position, which closes CSB1, CSB2, CSB3, CSB4 and CSB5, and opens CSM1 and CSM2. Other automatic controls open fan contactor F2 and close F4 at this time. These operations connect the traction motor fields to the main generator instead of their own armatures, and connect the dynamic braking resistors and fan motors to the traction motor armatures.

Dynamic braking differs greatly from air braking because the entire retarding force is exerted at the front end of the train instead of throughout its length, as when using the automatic air brake. The train is therefore bunched instead of being kept stretched as is frequently the case in automatic braking. Application or release of the dynamic brake will cause a corresponding adjustment in slack. Gradual changes in braking effort are therefore necessary in order to avoid damage to the train and its contents. The automatic brakes may function on

the train (but not on the locomotive), at the same time as dynamic brakes. This is frequently necessary, as for example:

- a. The dynamic brakes will not stop a train because the braking effort fades out at slow speed, and an application of air is necessary.
- b. Air may be used if grade or tonnage tends to increase the speed above sixty (60) miles per hour.
- c. Air must be used to control train speed through restricted zones below sixty (60) miles per hour, if the maximum dynamic braking limits have been reached.

When locomotive units are connected in multiple, dynamic braking can be obtained from any unit in service, even though some other unit is shut down. However, a shutdown unit reduces the braking effort proportionately. The entire effort of any individual unit is lost if:

- a. The engine control switch is "off" or "idle".
- b. The shutter limit switches fail to set for dynamic braking.
- c. The fan differential relay picks up, or the fan relay cut-out switch is open.
- d. The ground relay picks up.
- e. A traction motor cut-out switch is open. (Only one pair of motors per switch is cut-out in motoring, but both pairs are cut-out for braking.)
- f. Power Switch P2 fails to re-close.
- g. The Protective Braking Relay fails to drop-out (close).

PERFORMANCE LIMITS

The maximum speed at which dynamic braking is

practical is about 60 miles per hour. Above 60 miles per hour, only the air brakes should be used. A typical dynamic braking performance curve shows the range in braking effort which must always lie above the minimum field, and below the maximum field or maximum armature amperes. A braking-overload light (controlled by DB relay) warns the operator when the maximum armature load amperage is reached, and the characteristics of the throttle action limit the field amperes as indicated by the minimum and maximum field curves. At any given speed, advancing the throttle will increase the field amperes because of the throttle action on the Load Regulator, and on engine-generator speed. (The exact limits of the performance curve vary with different gear ratios or DB relay settings.)

Below speeds of 17 miles per hour, the braking effort is limited by the maximum field amperes because the maximum load cannot be reached at low speeds. Between 17 miles per hour and 60 miles per hour, the operator must keep within the maximum load amperage by reducing the throttle and applying air brakes if heavy tonnage and grade tends to cause overload.

It can be seen from the performance curve that as the speed increases for any given field current, the armature amperes and braking effort increases. Likewise, as the field is increased for any given speed, the armature amperes and braking effort increase. Such increases for any given train would result from increased grade.

If the load increases beyond the upper limits of the curve, service applications of the automatic air brake must be made in addition to the dynamic braking.

POWER CONTROL CONTACTOR

This contactor must be closed during dynamic braking, in order to energize P2 and complete the dynamic braking field circuit. The coil is fed through the same circuit in both motoring and braking, but the contacts are fed through a different circuit.

PROTECTIVE BRAKING RELAY

A protective braking relay PB is connected across the generator during dynamic braking to keep the traction motor fields disconnected until the generator

voltage dies down to normal braking voltage. This is done by feeding the coil of Power Switch P2 through the contacts of this relay. No current flows through the traction motor fields until P2 is energized by the relay.

DYNAMIC BRAKING CONTACTORS

Contactor BR1 can be energized only during dynamic braking, since its coil is fed by a wire from the dynamic braking position of the controller. Its main function is to connect protective braking relay PB across the generator during dynamic braking only.

When contactor BR2 is closed, it energizes the throttle valve to idle the engine, and opens the power circuits, thus preventing dynamic braking. If the Engine Control Switch, or the fan or traction motor cut-out switches are improperly set, BR2 closes.

SHUTTER LIMIT SWITCHES

The position of the shutters on the cooling system is different in dynamic braking than in motoring (see Shutter Valves). Shutter limit switches are mounted so that mechanical interlocking closes the braking switches SLB1 and SLB2 during dynamic braking. These switches are in the circuits feeding CSB on the cam switch and F4 in the fan control circuit. The corresponding motoring contacts SLM feed CSM on the cam switch and a portion of the fan control circuit. The respective circuits are not operative unless the shutter is properly set. The switches are above the operating cylinders.

CAM SWITCH

The traction motor circuit is converted to braking connection by a cam switch which has a motoring position and a braking position. It is operated by two magnet valves, CSM and CSB, built into the switch. Two main contacts are closed during motoring only, CSM1 and CSM2, and five main contacts are closed during braking only, CSB1, CSB2, CSB3, CSB4 and CSB5. Several fan control and power control circuits are fed through interlocks on this switch.

REGULATING RELAY

Dynamic brake limit relay, DB, is provided to give

warning of excessive load on the dissipating resistors. The relay is connected across these resistors, and closes when its setting is exceeded. If the load is not reduced by the engineer, the relay picks up and lights the brake overload light. The engineer should immediately reduce the throttle if this light comes on.

If there are two DB relays in the equipment cabinet, they are connected in parallel but are adjusted to slightly different settings. One relay will act on the load regulator to reduce the load automatically before the light comes on. Since the action is automatic, this feature need not concern the operator unless persistent burning of the light indicates sluggish action or faulty interlocking, which should be reported to maintenance men.

BRAKE INTERLOCKING VALVE

Dynamic braking may be supplemented by small service applications of air to the train if required, but the two braking systems are interlocked to prevent their simultaneous service application on the locomotive. Whenever the controls are set for dynamic braking, brake valve DIV is energized to accomplish the interlocking. Frequent sliding of the locomotive wheels would probably occur if this interlocking protection were not provided. The independent brake and the emergency brake will apply on the locomotive regardless of the setting of dynamic brake controls, and unrestricted use of the automatic brakes is maintained on the cars.

FAN CONTACTORS

During braking, the regulator negative return of the fan motors is broken at F2 and connected to the traction motor armatures by closing F4. F2 is de-energized (opened) by CSM9 interlock when the cam switch changes to braking position. F4 is energized (closed) when the interlocks are properly set for braking.

CONTROL SEQUENCE

For dynamic braking, the engine control switch and fan cut-out switch must be "on" and the Traction Motor Cut-Out Switch must be in normal running position. As previously stated it is necessary to:

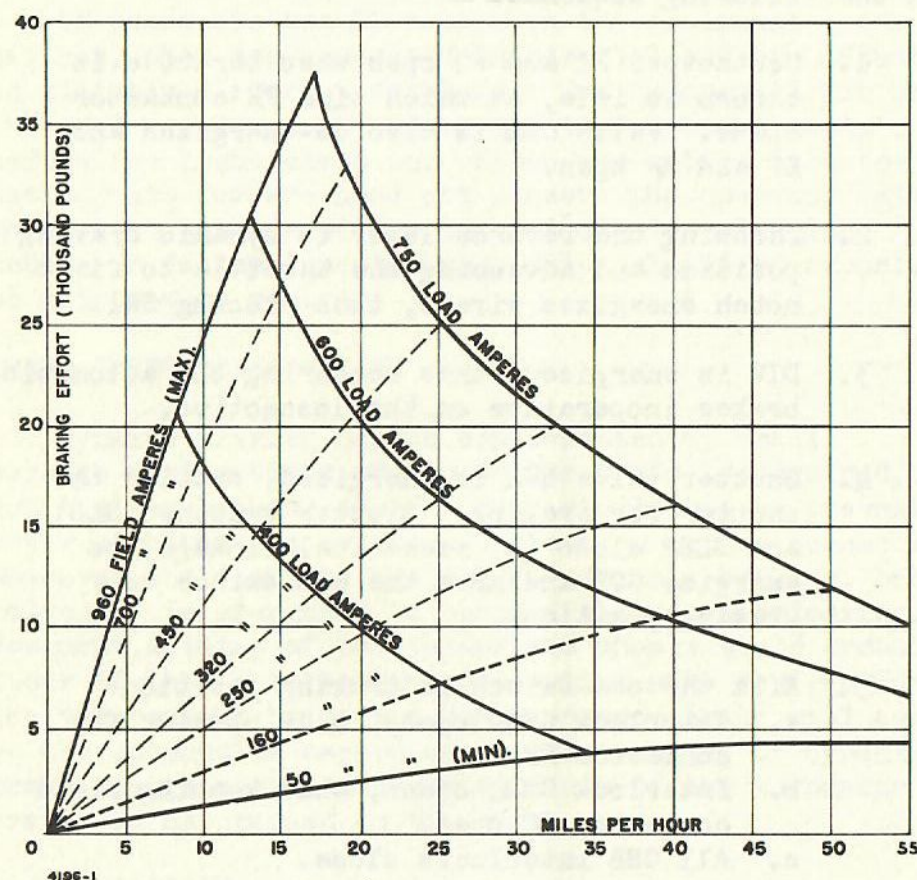
Open CSM1, CSM2, P1, EF and F2 switches and contactors.

Close CSB1, CSB2, CSB3, CSB4, CSB5, P2, EF (recloses) and F4.

The dynamic braking system functions automatically in the following sequence:

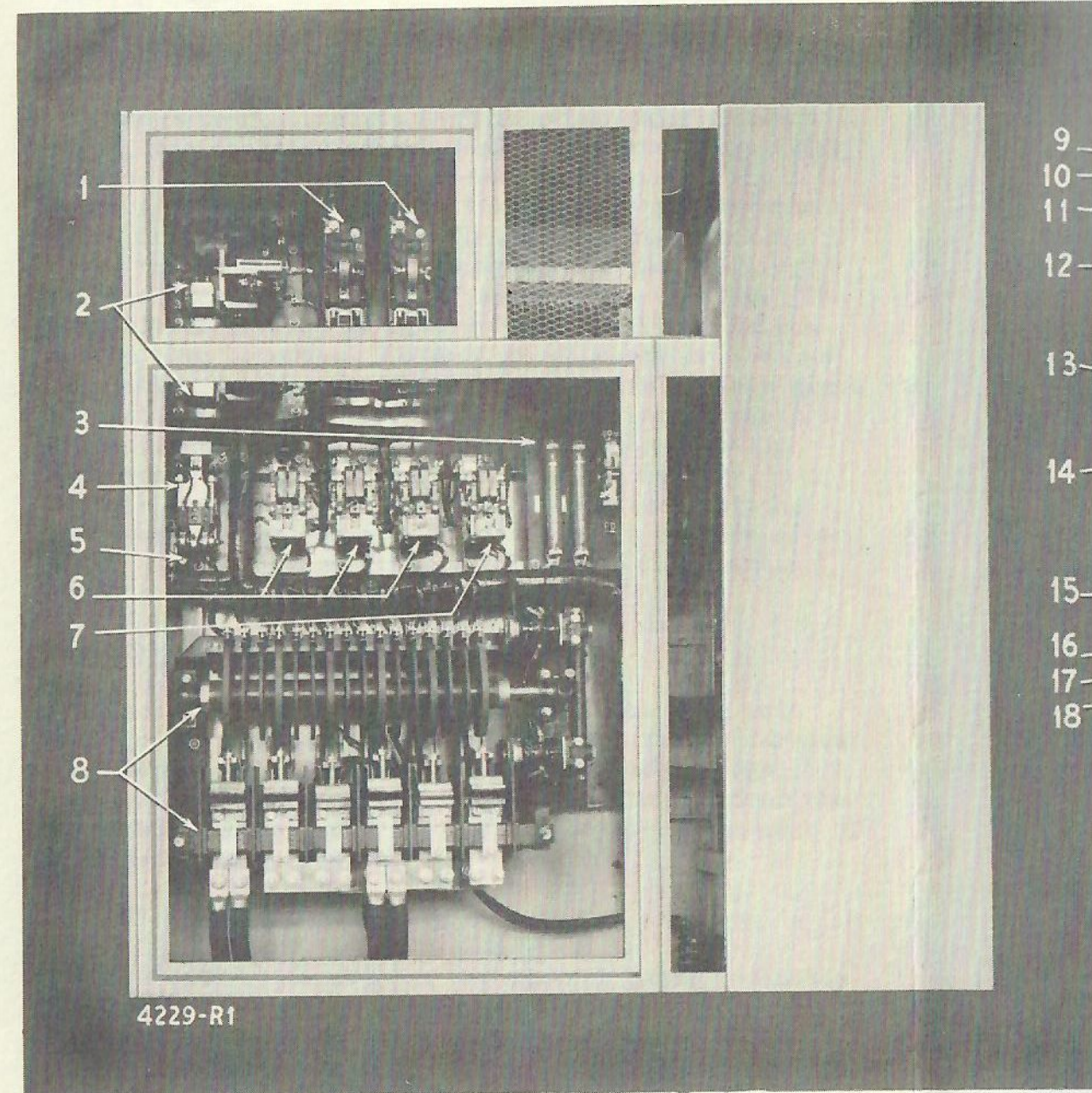
1. Contactors P1 and P2 open when throttle is thrown to idle, at which time FR contactor opens. Valve CSM is also de-energized and EF and GF open.
2. Throwing the reverse lever to dynamic braking position and advancing the throttle to first notch energizes wire D, thus closing BR1.
3. DIV is energized, thus rendering the automatic brakes inoperative on the locomotive.
4. Shutter valve SV2 is energized, setting the shutter for braking. Shutter switches SLB1 and SLB2 close (by mechanical linkage) to energize CSB and move the cam switch to braking position.
5. With the cam switch in braking position:
 - a. Interlock CSM9 opens, thus opening fan contactor F2.
 - b. Interlock CSM8 opens, thus keeping field contactor GF open.
 - c. All CSB interlocks close.
6. Fan circuit changes to braking connection:
 - a. F4 closes, being energized through wire D, shutter switch SLB1 and CSB10 interlock.
 - b. Interlock F4-in closes, closing FR.
7. When interlocks FR and CSB8 have closed, power switch P2 closes, providing the generator voltage has died down sufficiently to let PB relay drop out. The traction motor fields are thus connected to the main generator. Switch P1 does not close because CSM6 is open.

8. The exciter field is now fed through CSB11, CSB13 and CSB14. EF recloses after CSB12 and P2-in interlocks close, thus establishing field excitation, and completing the changeover to dynamic braking.



TYPICAL DYNAMIC BRAKING PERFORMANCE CURVE

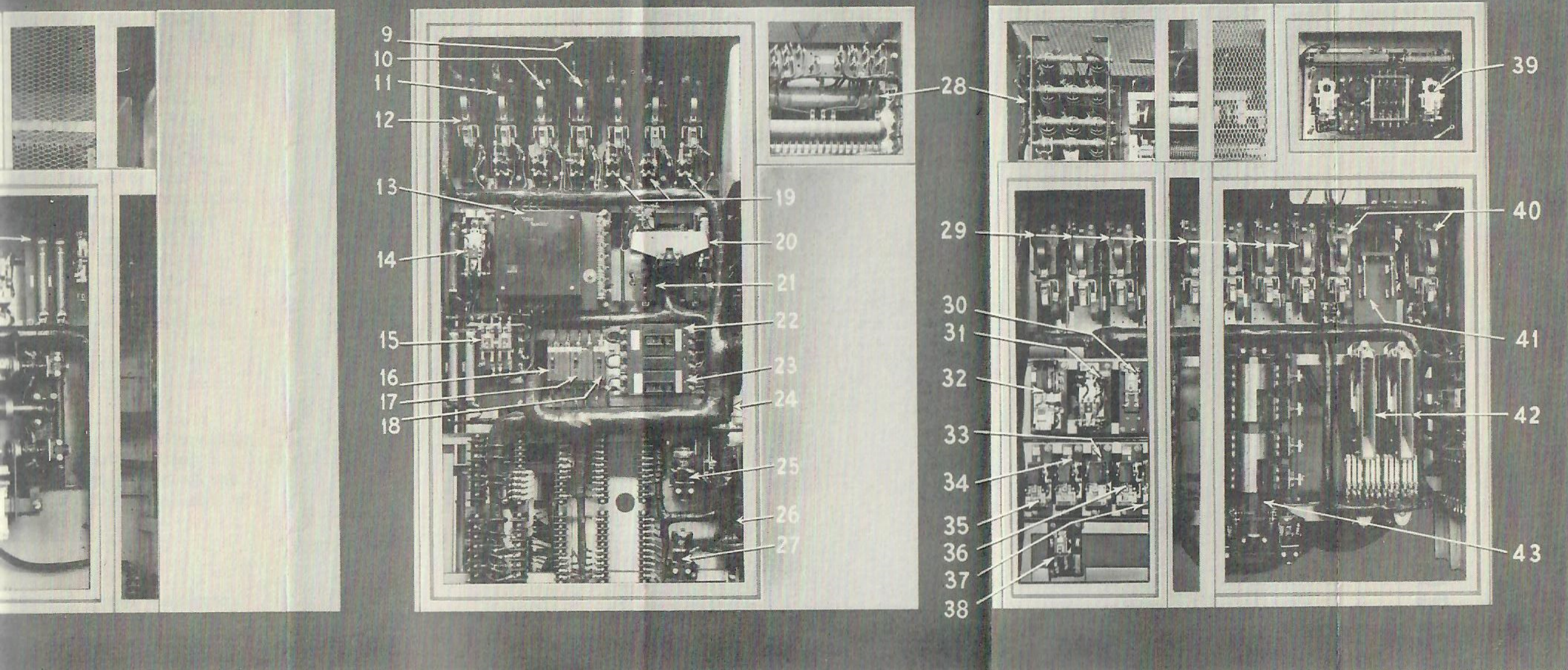
The braking effort may be determined from the curve by reading the vertical scale at a point horizontally opposite the intersection of the speed and ampere readings. For example, at 25 M.P.H., the braking effort is about 7500 pounds at 400 load amperes, 16,500 pounds at 600 load amperes, and 25,000 pounds at maximum load amperes. (There is no field ammeter, but the field current indicated on the curve for each of these conditions is 160 (minimum), 320 and 450 amperes respectively.) At 15 M.P.H., the braking effort is 4500 pounds at minimum field, 13,000 pounds at 400 load amperes, 27,000 pounds at 600 load amperes and 34,000 pounds at maximum field which is reached at a load slightly below the maximum load amperage.



4229-R1

- | | |
|---|----------------------------------|
| 1. Fan Motor Contactors, F4, F5 | 12. Reverse Current Con |
| 2. Dynamic Brake Limit Relays DB1, DB2 | 13. Voltage Regulator V |
| 3. Fan Differential Relay, FD | 14. Fan Motor Field Shu |
| 4. Protective Braking Relay PB | 15. Ground Relay GR |
| 5. Dynamic Braking Cut-out Switch | 16. Power Cut-Out Switc |
| 6. Dynamic Braking Control Contactors BR1, BR2, BR3 | 17. Lighting Switch (En Cabinet) |
| 7. Exciter Field Contactor EF3 | 18. Heater Fan Switch (|
| 8. Cam switch Group | 19. Fan Motor Contactor |
| 9. Thermo Switch (Fire Alarm) | 20. Reverse Current Rel |
| 10. Generator Field Contactors (Starting) GF1, GF2 | 21. Traction Motor Cut- |
| 11. Generator Field Contactor GF | 22. Fan Motor Switch |
| | 23. Auxiliary Generator |

Electrical Equipment



- | | | | |
|---|---|--|--|
| 9. Fan Motor Field Shunt Relay R | 12. Reverse Current Contactor A | 24. Master Control Valve MCV | 34. Control Contactor CR1 |
| 10. Fan Motor Field Shunt Relay R | 13. Voltage Regulator VR | 25. Time Delay Relay, TD | 35. Control Contactor CR |
| 11. Fan Motor Field Shunt Relay R | 14. Fan Motor Field Shunt Relay R | 26. Throttle Valve, TV | 36. Exciter Field Contactor EF |
| 12. Reverse Current Contactor A | 15. Ground Relay GR | 27. Sanding Valve, FSV
(Also RSV on "B" Units) | 37. Power Control Contactor FR |
| 13. Voltage Regulator VR | 16. Power Cut-Out Switch | 28. Resistors | 38. Signal (Alarm) Relay, SG |
| 14. Fan Motor Field Shunt Relay R | 17. Lighting Switch (Engine Room and Cabinet) | 29. Traction Motor Field Shunt Contactors | 39. Traction Motor Field Shunting Controller |
| 15. Ground Relay GR | 18. Heater Fan Switch ("A" Units Only) | 30. Wheel Slip Relay, WS1, WS2 | 40. Engine Starting Contactors
G1, G2 |
| 16. Power Cut-Out Switch | 19. Fan Motor Contactors F1, F2, F3 | 31. Protective Starting Relay, PT | 41. Battery Switch |
| 17. Lighting Switch (Engine Room and Cabinet) | 20. Reverse Current Relay RC | 32. Engine Stop Contactor, ES | 42. Pneumatic Power Switches P1, P2 |
| 18. Heater Fan Switch ("A" Units Only) | 21. Traction Motor Cut-Out Switches | 33. Power Knockout Contactor, PK
("A" Units only) | 43. Reverser |
| 19. Fan Motor Contactors F1, F2, F3 | 22. Fan Motor Switch | | |
| 20. Reverse Current Relay RC | 23. Auxiliary Generator Switch | | |

Note: On some designs, F5, BR3, EF3, R, and power cut-out switch (item 16) are omitted.

TYPICAL ELECTRICAL EQUIPMENT CABINET

BATTERY & STARTING CIRCUITS

The Battery Circuits fall into two main distinct parts, the charging circuit and its related regulating devices, and the starting circuits. Whenever the starting circuit is brought into use by pressing the start button, the Starting Contactors automatically close to connect the main generator to the battery, and the Exciter Contactor EF opens automatically. The manually controlled Auxiliary Generator Field Switch should also be open. The Auxiliary Generator and its regulating devices are therefore inactive at that time. As soon as the engine starts, the Starting Contactors are automatically de-energized which automatically disconnects the Main Generator from the battery. Certain items such as the lube oil pressure switch, fuel pump and shutdown valve continue in service after starting, but are so closely related to the starting circuit that they are described here.

BATTERY AND BATTERY CUT-OUT SWITCH

Each locomotive unit is equipped with a 64 volt storage battery mounted beside the fuel tank underneath the locomotive. A manually operated, double pole, single-throw knife switch, located in the front of the equipment cabinet, disconnects the battery from most of the electrical circuits.

BATTERY CHARGING

The battery ammeter on the control panel indicates the rate of charge or discharge. The battery is automatically charged by the auxiliary generator which is controlled by a vibrating type voltage regulator so that the voltage is substantially constant at the various operating speeds of the Diesel engine. The reverse current relay automatically connects the battery and the auxiliary generator after the engine starts. This equipment is described in the following paragraphs. The battery may also be charged from terminal or shop circuits through the outside battery charging receptacle at the battery box.

VOLTAGE REGULATOR

The voltage regulator in the front of the equipment cabinet holds the auxiliary generator voltage constant over the normal operating speed range of the Diesel

engine. A voltage relay element varies the auxiliary generator shunt field current to hold constant voltage regardless of engine speed and auxiliary load. The intermittent operation or vibration of the moving contacts causes a light sparking which is audible at close proximity. The rheostat in the regulator is adjusted to give proper generator voltage and should not be changed by unauthorized personnel.

REVERSE CURRENT RELAY AND CONTACTOR

The reverse current relay has two automatic functions. It connects the auxiliary generator to the battery through contactor A when the generator voltage is sufficiently high to charge the battery, and protects against a reverse flow of current from the battery, when the generator voltage is too low, by opening the circuit.

Connections are made by means of voltage coils which close contacts in the circuit to contactor A when the generator voltage is about 1 volt above battery voltage. After the contactor closes, this voltage no longer affects the relay. It is therefore necessary to open the circuit by means of another coil which measures the current in the circuit between the auxiliary generator and battery. This coil opens contactor A when the reverse current reaches a magnitude of about 20 to 25 amperes. Both the relay and contactor are located in the electrical equipment cabinet.

ENGINE SHUTDOWN VALVE

This solenoid-operated valve controls the fuel supply through coil SDV which must be energized to maintain fuel supply. A circuit through the starting button energizes this coil when starting the engine. As soon as oil pressure builds up, the lube oil pressure switch closes and keeps the coil energized after the start button is released. When the engine is operating, it shuts down if SDV is de-energized by opening the Engine Control Switch, the Lube Oil Pressure Switch, the 35-amp. Control Breaker or the ES Contactor. Other details of this valve are shown in a diagram in Section 3.

FUEL SUPPLY PUMP

The motor driven fuel supply pump for each power unit receives power through the normally closed shutdown contactor ES and the engine control switch. The compound-wound motor mounted on the bedplate on the valve gear (operating) side of each engine operates at constant speed, supplying fuel oil from the supply tank to the engine fuel injection pumps. Closing the emergency shutdown switch on the engineer's control stand energizes shutdown relay ES on all "A" and "B" units in multiple, opening all circuits to the fuel pump motors and cutting off the fuel supply.

LUBE OIL PRESSURE SWITCH

Each unit has a Lube Oil Pressure Switch mounted on the engine, which automatically opens when lubricating oil pressure drops below a predetermined value. It functions through the shutdown valve which was just described.

STARTING CIRCUIT

Start Button #1 is mounted on the engine control panel, and controls the Electro-Magnetic Starting Contactors. It is fed through the engine control switch which must be in "on" or "idle" position to obtain power from the battery. When the button is held in, the contactors GF1 and GF2 in the generator field circuit, and the starting contactors G1 and G2 in the generator armature circuit are closed. The current from the battery then flows to the main generator which now acts as a motor and cranks the Diesel engine. When the engine turns over, Start Button #2 should be pressed, opening contactor GF2, which weakens the generator field and increases the speed of the generator to the engine firing speed. The starting contactors are located in the electrical equipment cabinet.

Armature contactors G1 and G2 are interlocked to prevent them from closing until the field contactors GF1 and GF2 are closed. If this were not done, the armature would short circuit the battery. When lube oil pressure has built up to 20 pounds, the Lube Oil Pressure Switch automatically changes to its normal operating position which keeps SDV (in the fuel supply line) energized, regardless of the position of the

Start Button. The Start Buttons may then be released. The gauge indicating the oil pressure is adjacent to the Start Buttons. (Note: Start Button #1 has a second set of normally closed contacts which are opened during starting to disconnect EF and GF.)

PROTECTIVE STARTING RELAY

A protective starting relay PT picks up as soon as normal battery voltage is exceeded. This de-energizes (opens) G1 and G2 which disconnects the main generator as soon as the engine fires and prevents it from feeding the battery.

LOAD REGULATOR

A load regulator is connected in series with the exciter 4-pole field circuit. It automatically changes the resistance in the field circuit, thereby changing the strength of the field to adjust the load on the electrical equipment. Its main function is to reduce the field strength, and hence the power output of the main generator, whenever the engine tends to become overloaded. The description in the maintenance bulletin should be understood before making any adjustment to the regulator.

AUXILIARY GENERATOR SWITCH

A breaker type switch in the auxiliary generator circuit affords overload protection by automatically tripping when current is excessive. The switch is in the equipment cabinet and is normally kept closed.

AUXILIARY GENERATOR FIELD SWITCH

A manually operated breaker type switch in the auxiliary generator field circuit is located on the engine control panel. It is opened when locomotive is shut down and closed after starting the engine.

EXCITER CIRCUIT

In motoring, field contactors GF and EF are closed. The exciter feeds the main generator field through GF, and the auxiliary generator feeds the exciter 4-pole field through EF and the load regulator. During dynamic braking, only EF is closed.

A I R S Y S T E M

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A I R S Y S T E M

GENERAL DESCRIPTION

Compressed air is used on the locomotive for actuation of the air brakes, throttle, radiator shutters, sanders, window wipers, signal horns, and miscellaneous equipment. In addition, compressed air from the locomotive is supplied to the entire train for brake operation. Each unit of the locomotive has a complete air system which may be used independently. When units are used together, however, their air systems are joined together at connections at the ends of the units.

Each diesel engine drives an air compressor which draws air from the interior of the engine room and pumps it into the air reservoirs. The air operated devices throughout the locomotive are connected, through suitable cut-off or pressure-varying valves, to the air reservoirs. A schematic diagram of the air system will be found at the end of this section.

AIR COMPRESSOR AND RESERVOIR SYSTEM

The air compressors are of the two-stage type. The low-pressure cylinders of the compressors pump air through an intercooler to the high-pressure cylinder. The high-pressure cylinder then pumps the air into lines leading to the main reservoirs. The compressors are fitted with load-and-unload arrangements for maintaining the desired reservoir pressure. The compressors are controlled by an air compressor governor connected to the main reservoir system. This governor causes the compressors to load and unload at 125 psi and 140 psi reservoir pressures, respectively. When the compressors are "loaded", they pump air normally; when they are "unloaded", the moving parts reciprocate normally, but valves are opened to prevent the pumping of air.

The air from the compressors passes first into a sump reservoir and then into the two main reservoirs. A cooling coil is located in the line between the first and second main reservoir. Automatic drain valves between the main reservoirs, and ahead of the first reservoir drain the condensed moisture from the air. Safety valves are located adjacent to the compressor and at the outlet of the first main reservoir to prevent overloading of the system.

When two or more locomotive units are operated together, connect the main reservoir systems at the end connections and open the main reservoir cut-off valves between the units. In the event of an engine or compressor failure in one unit, full reservoir pressure will be maintained by compressors in the other units.

An auxiliary reservoir is connected to the main reservoir through a reducing valve which maintains 70 pounds pressure on the pneumatic control lines. The pressure gauge for the control system is located underneath the engine room steps on "A" units, and at hostler's rack on "B" units.

AIR BRAKE SYSTEM

For complete information on air brake equipment, consult Westinghouse Air Brake Company publications. Standard 24RL equipment with Automatic Brake Valve and Independent Brake Valve is installed on "A" units, with Rotair Valve suitable for the service in which the locomotive is to be operated. Hostler's Brake Valve is supplied on "B" units. Other valves appearing in the Piping Diagram regulate overspeed brake applications, power knockout switch, deadman control. Operators should be familiar with various cut-out cocks, dead-engine cock, safety control cock, etc., and their position in leading and trailing units.

Where K2A Rotair valve is used, and no controlled emergency pipe is carried between units, the controlled emergency cut-out cock on "B" units must be set for the type of service (pass or frt). With K2 Rotair valve, there is no cock, nothing need be done on "B" units, and the valve on trailing "A" units should be in "lap"

PNEUMATIC THROTTLE SYSTEM

The load regulator and engine governor are operated by pneumatic actuators which receive a controlled air supply through the master controller. Two magnet valves, (MCV and TV), are installed in the throttle piping. When master control valve MCV is energized through the control switch, the throttle on that unit controls all engines in multiple, no other throttle being operative. When throttle valve TV is energized (by wheel slip, hot engine, isolation, etc.) it vents the air from the actuator to idle the engine.

HORN, BELL, WINDOW WIPER, AND SANDING SYSTEMS

These systems are connected directly to the main reservoir system. The horn, bell, and window wiper lines, (and washer if installed) are each equipped with manual valves located at the control position.

The flow of air through the sand nozzles is controlled by magnet valves which are connected electrically to the sander switch. The sander switch (on "A" units only) is air operated from the sanding bail, or automatically during an emergency brake application. When locomotives are operated in multiple, the sander magnet valves of all units are energized through the sander switch in the controlling "A" unit. The connections between the sander switch and the sander valve are so interlocked with the reversers that sand is applied to the wheels in the direction of locomotive travel only.

AIR COMPRESSOR UNLOADING SYSTEM

The purpose of the air compressor unloading system is to maintain the main air reservoir pressure within the desired limits by causing the compressors to operate with or without load as necessary. The compressors are equipped with unloading devices in the cylinder heads above each intake valve. To unload the compressor, the unloader locks the compressor intake valves open preventing the pumping of air, although the compressor continues to reciprocate normally. The unloaders are actuated by air at main reservoir pressure under the control of an air compressor governor. The governor is an air-operated valve which is also actuated by main reservoir air pressure. When the reservoir air pressure reaches 140 psi, the governor responds by shutting off the air to the unloader and exhausting the pressure from the unloader air lines; as a result, the compressors begin to pump air. Thus, air reservoir pressure in the range of 125-140 psi is automatically maintained at all times when the locomotive is in operation.

When locomotive units are operated in multiple, each S-16 compressor governor is connected electrically through the train line receptacle to the compressor valves on all units. This synchronizes all air compressor so they load and unload at the same time in response to the compressor governor in any unit.

ELECTRO-PNEUMATIC EQUIPMENT

The electro-pneumatic equipment in the diagram on page 607, and listed on page 606, is described in detail in the Electrical Section. Except for a few special applications described in the following paragraphs, their pneumatic action is obvious. They are connected to the 70 psi air supply.

POWER SWITCHES, REVERSERS, AND CAM SWITCH

Integral magnet valves control the air supply to and from the operating cylinders of this equipment. These cylinders actuate the high voltage contacts of the switches and reversers. The reverser has two valves, one of which is actuated when the controls are set for forward travel, and the other for reverse travel. The cam switch has two valves, one of which is actuated during dynamic braking to establish the braking circuits, while the other valve establishes the motoring circuits.

If the control pressure is normal and this equipment does not function, the coil may be burned out. To move the reverser or cam switch under these circumstances, press the plunger in base of magnet valve.

WATER TEMPERATURE CONTROL AND SHUTTER OPERATING SYSTEMS

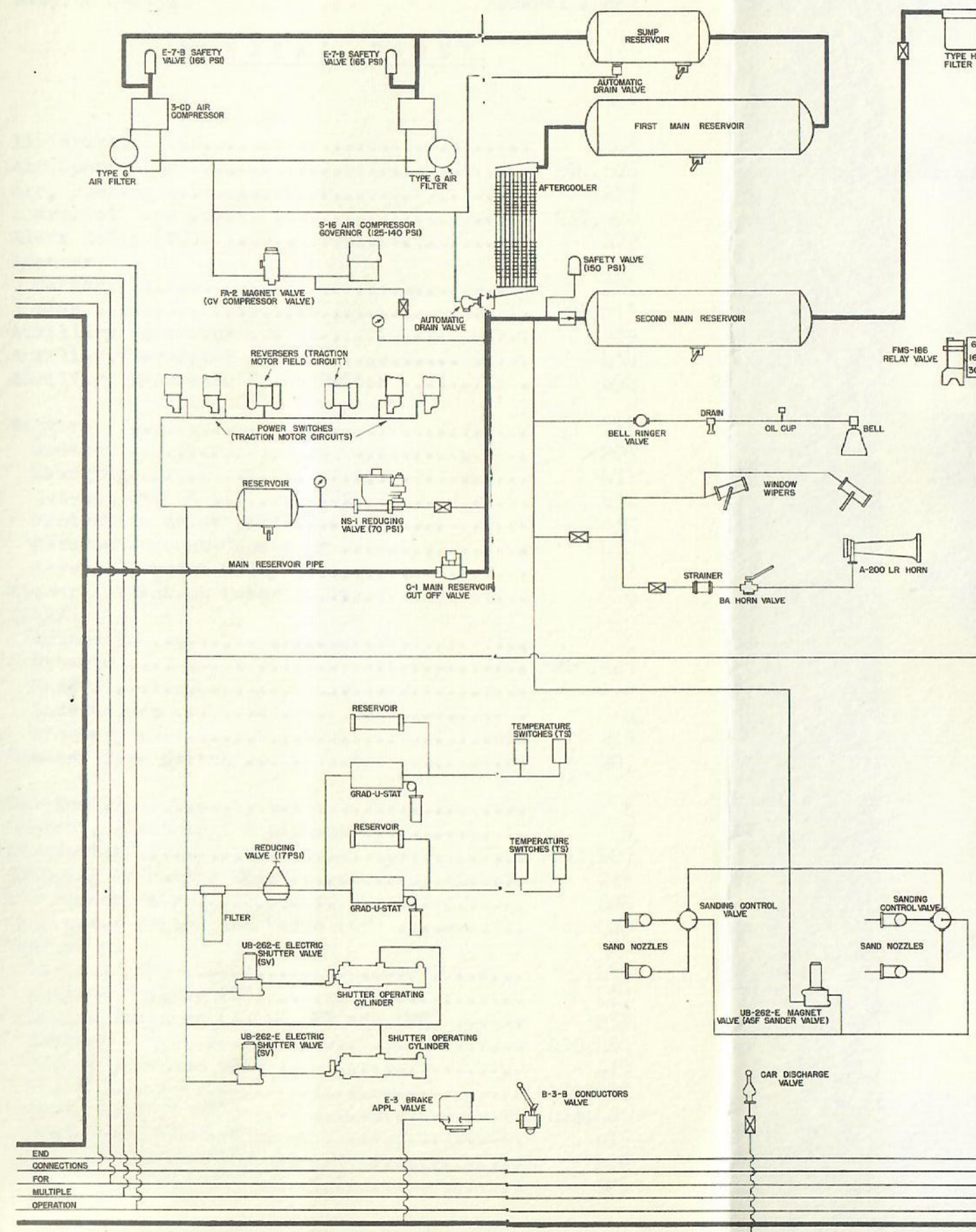
The radiator shutters are operated by air cylinders (or engines) which receive air from the main reservoir system. Electrically operated shutter valves (described in Electrical Section) control the air lines to the shutter's operating cylinder. The actuation of the shutter valves depends primarily on whether the control circuits are set for motoring or dynamic braking. A pneumatic step controller (into which are built the temperature switches in the fan control circuit) is actuated by the engine temperature thermostat as described on page 305.

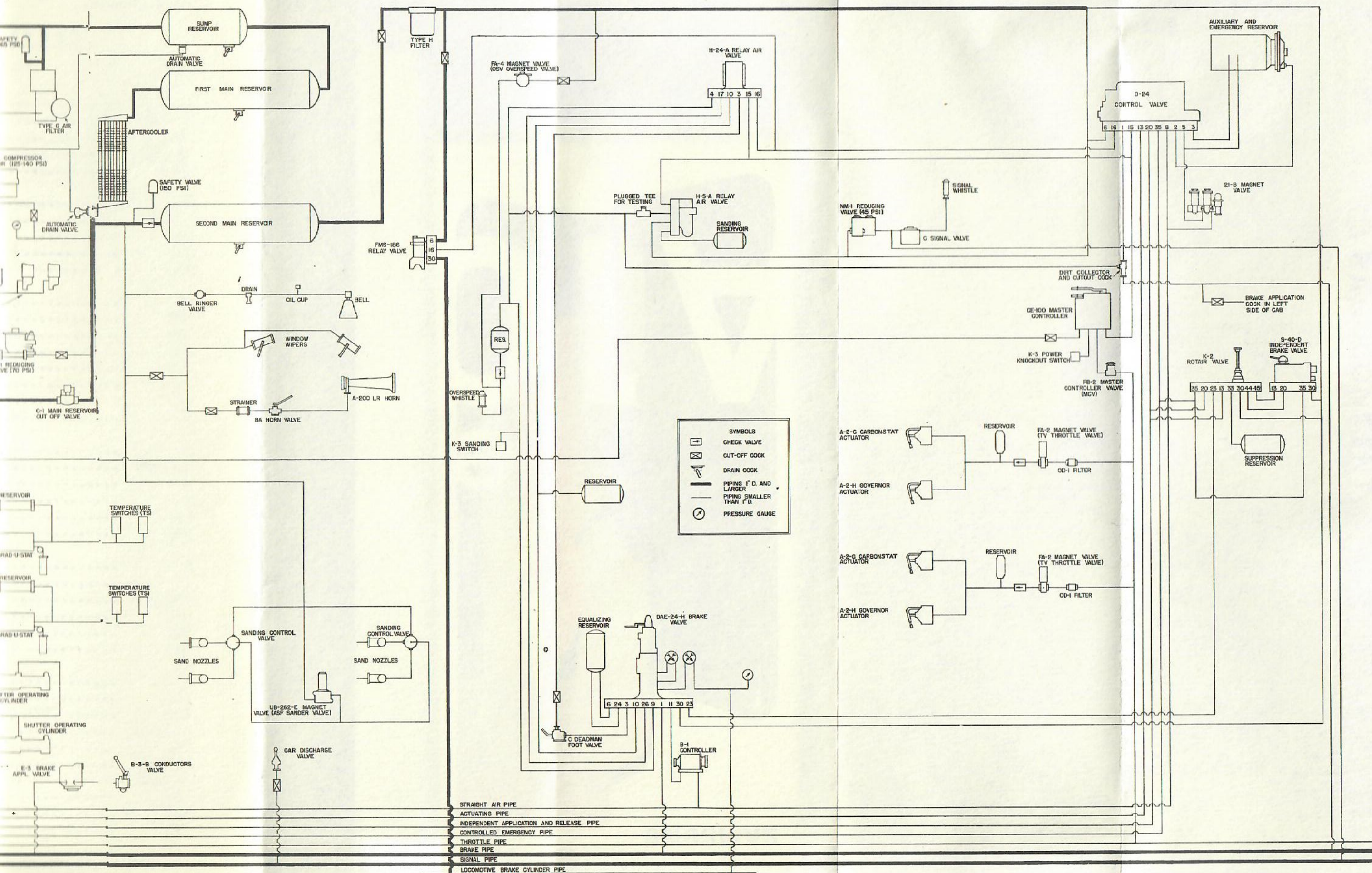
TIME DELAY RELAY

The time delay relay consists of a magnet valve and an air cylinder and piston for the operation of an electrical interlock. Due to the small size of the valve, the passage of the air requires several seconds before the interlock responds to the magnet coil. It prolongs the time between the opening of the low voltage fan motor contacts and the closing of the high voltage fan motor contacts.

LIST OF ELECTRO-PNEUMATIC EQUIPMENT IN PIPING DIAGRAMS

Symbol	Item	Function
TV	Throttle Valves	Reduce throttle line pressure automatically.
--	Compressor Governor Switch	Controls compressor loading.
CV	Compressor Valve	Compressor Pumping.
PKS	Power Knockout Switch	Idles engine and opens power circuits during emergency brake application.
P	Power Switches	Connect traction motors to main generator.
FOR REV	Reverser	Reverses traction motor field circuits.
CSM CSB	Cam Switch	Changes traction motor connections for dynamic braking.
SV	Shutter Control Valve	Controls air to shutter operating cylinders.
TD	Time Delay Relay	Times operation of fan motor contactors.
DBV	Brake Regulating Valve	Reduces braking overloads.
DIV	Brake Interlock Valve	Prevents application of automatic or independent air brakes to locomotive during dynamic braking.
MCV	Master Control Valve	Prevents accidental use of throttle in trailing unit.
OSV	Overspeed Valve	Locomotive speed.
FSV RSV	Sanding Valves	Controls air to sand nozzles.





AIR PIPING DIAGRAM
Figure 1

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